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Arachnologische Mitteilungen

European Arachnology 2014

24.-29.8.2014 Torino, Italy
www.european-arachnology.org

Heft 49 **Karlsruhe, Juni 2015**

ISSN 1018-4171 (Druck), 2199-7233 (Online) www.AraGes.de/aramit

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Arachnologische Gesellschaft e.V.
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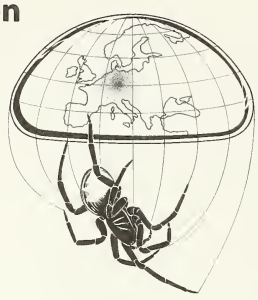

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Erscheinungsweise:
Pro Jahr 2 Hefte. Die Hefte sind laufend durchnummeriert und jeweils abgeschlossen paginiert.
Der Umfang je Heft beträgt ca. 50 Seiten. Erscheinungsort ist Karlsruhe. Auflage 400 Exemplare
Druck: Druckerei Isensee, Oldenburg.

Autorenhinweise/Instructions for authors:
bei der Schriftleitung erhältlich, oder unter der URL: http://www.arages.de/aramit/

Bezug:
Im Mitgliedsbeitrag der Arachnologischen Gesellschaft enthalten (25 Euro, Studierende 15 Euro pro Jahr), ansonsten beträgt der Preis für das Jahresabonnement 25 Euro. Die Kündigung der Mitgliedschaft oder des Abonnements wird jeweils zum Jahresende gültig und muss der AraGes bis 15. November vorliegen.

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Die Bezahlung soll jeweils im ersten Quartal des Jahres erfolgen auf das Konto:
Arachnologische Gesellschaft e.V.; Kontonummer: 8166 27-466; Postbank Dortmund, BLZ 440 100 46
IBAN DE75 4401 0046 0816 6274 66, BIC (SWIFT CODE) PBNKDEFF

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Umschlagzeichnung: P. Jäger, K. Rehbinder

Preface to the section of the Proceedings of the 28th European Congress of Arachnology, Torino, 2014 Aug. 24-29 (pp. 1-54)

I remember very well the exact moment when our estimated former President, Ferenc Samu, together with our new President, Wolfgang Nentwig and the omnipresent Theo Blick, called me away during the Israeli meal at the 2011 congress in Israel. "These guys look pretty serious – I thought – what is wrong with them?" I could not imagine that they were trying to put on my shoulders the responsibility for organizing the 28th European Congress of Arachnology! I had a little hesitation, but I could not see any doubt in their subtle kindly threatening expression, which meant that the decision was already taken and that there was just one possible answer to their question.

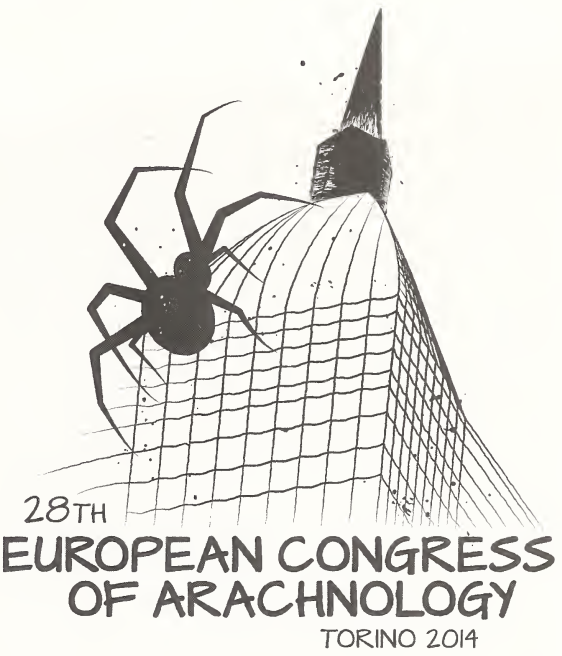
If, from one side, I had no time for taking the decision, from the other, there was enough time for the organization: in three years I could try to make a good job. Back in Italy, a few months later, I assembled the team and the adventure started.

The "core" of the organization team was composed both by arachnologists and non-arachnologists, and all of them were (and still are) very good friends: Mauro Paschetta, Alberto Chiarle, Raquel Galindo, Rocco Mussat, Elena Piano Sr and Stefano Mammola. In the last weeks before the meeting, the team grew up with 8 more volunteers joining the group.

The Congress was attended by 225 participants (including 27 accompanying persons and 15 members of staff) from 41 countries. Beside European countries, we hosted people coming from New Zealand, Australia, Mexico, USA, Uruguay, Japan, China, Iran, Pakistan, India and Taiwan.

As they told us many times (especially during the evening entertainments!), people had a lot of fun during the congress!

The scientific program itself was split over four days of talks, and comprised 5 plenary talks, 81 oral presentations and 81 posters that encompassed a wide breadth of arachnological research, with 22 thematic sessions (12 for oral presentations and 10 for posters) in addition to three special symposia. A wide range of contributed talks followed each plenary, many of which were given by students. The talks were split into subject areas such as behavioural and community ecology, functional morphology, biogeography, systematics and faunistics, phylogeography



and phylogenetics. Three special symposia placed at various stages throughout the congress also added focal points, covering topics such as invasive species, mating strategies and spider genomics.

The plenary talks given throughout the conference illustrated the breadth of research covered at the meeting. Martin Entling gave the first talk of the conference, on trophic interactions in spiders and their importance in ecosystems and Lucia Kuhn-Nentwig started off the sessions on the second day with a talk on the complexities of venom evolution. On day three Erhard Christian fascinated the entire audience with a talk on the hidden world of palpigrades, which was the first ever Arachnological Society plenary lecture to feature these remarkable arachnids, and Gustavo Hormiga described the evolutionary history of orb-weaving spiders in light of data acquired using new genetic tools. Last but not least, Frederick Hendrickx was the fifth plenarist, with a fascinating talk on evolutionary ecology in *Oedothorax*.

The congress excursions took place after two full days of conference talks, and allowed for relaxation or hard hiking – depending on which tour partici-

1 Galina Fet, 2 Ersen Aydın Yağmur, 3 Eva Liznarová, 4 Lucia Kuhn-Nentwig, 5 John Haymoz, 6 Miguel Richard, 7 Malayka Picchi, 8 Vladimír Hula, 9 Mert Elverici, 10 Jana Niedobová, 11 Paolo Glerean, 12 Holger Frick, 13 Efrat Gavish-Regev, 14 Francesco Ballarin, 15 Giulio Gardini, 16 Alireza Zamani, 17 Igor Armiach, 18 Roman Bucher, 19 Laia Mestre, 20 Guadalupe Corcobado, 21 Julieta May Morales, 22 Alberto Chiarle, 23 Alesandro Valdez Mondragón, 24 Nollie Hallensleben, 25 Mauro Paschetta, 26 Arthur Decae 27 Paolo Pantini, 28 Roland Stockmann, 29 Marco Isaia, 30 Paolo Tongiorgi 31 Aldo Mulas, 32 Patrick Boussès, 33 Jacopo Orlandini 34 Christine Rollard, 35 Elena Piano Jr. 36 Marie-Louise Célérier, 37 Peter Koomen, 38 Isidoro Riondato, 39 Martina Dalle, 40 Raquel Galindo, 41 Stefano Mammola, 42 Elena Piano Sr., 43 Davide Giuliano, 44 Alberto Doretto, 45 Mauro Fanelli, 46 Christian Komposch, 47 Gustavo Hormiga, 48 Shichang Zhang, 49 Victor Fet, 50 Erhard Christian, 51 Gabriele Uhl, 52 Luis Fernando García, 53 Yael Lubin, 54 Rachel Werneck, 55 Raluca Bancila, 56 Nataša Sivec, 57 Bernhard Huber, 58 Torbjörn Kronestedt, 59 Karin Sindemark Kronestedt, 60 Gustavo Silva de Miranda, 61 Jörg Wunderlich, 62 Dakota Piorkowski, 63 Brigitte Schmidt-Blick, 64 Theo Blick, 65 Jay Stafstrom, 66 Christian Kropf, 67 Loris Matani, 68 Shou-Wang Lin, 69 I-Min Tso, 70 Marzio Cometa, 71 Enrico Simeon, 72 Rainer Neumann, 73 Alessio Trotta, 74 Jutta Schneider, 75 Jannis Liedtke, 76 Wolfgang Nentwig, 77 Oliver Wearing, 78 Raju Mangaly, 79 Tomas Nowicki, 80 Marjan Komnenov, 81 Sara Goodacre, 82 name not known, 83 Tucker Gilman, 84 Radek Michalko, 85 Irina Marusik, 86 Robert Bosmans, 87 Yuri Marusik, 88 Ondřej Košulič, 89 Katrin Kunz, 90 Anna Nekhaeva, 91 name not known, 92 Anne-Sarah Ganske, 93 Henrik Krehenwinkel,

94 Aline Moser, 95 Gergely Ambrus, 96 Marij Decleer, 97 Jonas Wolff, 98 Pao-Chen Huang, 99 Jobi Joseph, 100 Csaba Szinetár, 101 Lenka Sentenská, 102 Boris Zakharov, 103 Simon Wittwer, 104 Jakob Walter, 105 Andrei Tanasevitch, 106 Ferenc Samu, 107 Pavel Just, 108 Benjamin Eggs, 109 Martina Pavlek, 110 Orsolya Beleznai, 111 Milan Řezáč, 112 Siegfried Huber, 113 Stano Pekár, 115 Andreas Fischer, 116 Luka Katušić, 116 Petr Dolejš, 117 Jens Runge, 118 Martin Entling, 119 Christoph Hörweg, 120 Jan Raška, 121 Peter Michalik, 122 Christo Deltshev, 123 Peter Jäger, 124 Elisabeth Bauchhenß, 125 Maria Chatzaki, 126 Beate Martens, 127 Cor Vink, 128 Marija Biteniekytė, 129 Jochen Martens, 130 Brent E. Hendrixson, 131 Hirotsugu Ono, 132 Janet Beccaloni, 132 Liana Lasut, 134 Ellen Akkersdijk, 135 Rebecca Godwin, 136 Tamara Spasojevic, 137 Nicole Garrison, 138 David Nagy, 139 Sandra Preiml, 140 Lior Ventura, 141 Katalin Sólyom, 142 Vera Opatova, 143 Peter‚Otto' Horak, 144 Gordana Grbic, 145 Anda Babalean, 146 Helga Heiling, 147 Pedro Sousa, 148 Zhisheng Zhang, 149 Gudrun Horak, 150 Sean Blamires, 151 Stanislav Korenko, 152 Angelo Bolzern, 153 Zsuzsanna Debnár, 154 Barbara Thaler-Knoflach, 155 Paula Chushing, 156 Bence Tajthi, 157 Miquel Arnedo, 158 Luis Crespo, 159 Victor Tudorica, 160 Gyula Szabó, 161 Chris Hamilton, 162 Seppo Koponen, 163 Heli Hurme, 164 Cristiana Tuni, 165 Jason Bond, 166 Paul Selden, 167 Maura Selden, 168 Patricia Velado Lobato, 169 Frederik Henderickx, 170 Léon Baert, 171 Martin Forman, 172 Plamen Mitov, 173 Paolo Ghislandi, 174 Peter van Helsdingen, 175 Konrad Wiśniewski, 176 Zheng Cao, 177 Shlomi Aharon, 178 Rahşen Kaya

pants had selected. The toughest trip involved a hike up to the Rifugio Questa in the Alpi Marittime National Park. Participants on this tour were fortunate to encounter several individuals of *Vesubia jugorum*, a rare lycosid species, which became a real talking point. Others opted for a more leisurely hike in the Alpi Marittime, to the Royal Hunting Lodge where we were served a delicious meal, which we enjoyed in the sunshine. Further tours were enjoyed to the Venaria royal residence and Mandria National Park, and a wine tasting excursion took place in the Langhe region, with the opportunity to explore the wine region.

The Torino meeting represented an important milestone in the Society, with several important matters decided, such as the election of our new president, Wolfgang Nentwig.

We congratulate again the winners of the best student oral presentations, Nicole Garrison, Vera Opatova and Katrin Kunz and the best posters, Anne-Sarah Ganske, Gustavo de Miranda and Gordana Grbic. Awards were kindly provided by our sponsors, although selection amongst so many high quality student presentations was difficult.

The awards ceremony was not only for talks and posters but also for photography. With his picture entitled 'Spotted by Spider', Peter Koomen won a trip to Ultima Frontiera, a private reserve in the Danube delta, an area of outstanding natural beauty that is designated by UNESCO as a World Heritage site and Biosphere Reserve.

In addition to the European Arachnological Society, the congress was under the patronage of Regione Piemonte, Provincia di Torino and Città di Torino. The main sponsors and collaborators were the Museo Civico di Scienze Naturali Enrico Caffi of Bergamo, the British Arachnological Society, Arachnologische Gesellschaft, Pensoft Publishers, Fondazione Cassa di Risparmio di Torino (CRT), Università di Torino and Compagnia di San Paolo, Terredavino - Cantine in Barolo, SKUA Nature Group, Siri Scientific Press, Società Entomologica Italiana, Museo Regionale di Scienze Naturali di Torino, EDISU Piemonte, Pelagosphera, Turismo Torino, Parco Regionale La Mandria, Parco Naturale Alpi Marittime, Grotte di Bossea and Forteto della Luja.

Finally, only five manuscripts in total were submitted from the Torino congress, of which all withstood the peer review and were evaluated as appropriate for publication.

I take this opportunity to thank again all congress participants and all the people involved in the Organization (see http://www.eca2014.it). It has been a precious and unforgettable experience, sometimes tough, sometimes funny and really amazing.

See you all soon at the next ECA meetings!

Marco Isaia (marco.isaia@unito.it)

A collection of horseshoe crabs (Chelicerata: Xiphosura) in the National Museum, Prague (Czech Republic) and a review of their immunological importance

Petr Dolejš & Kateřina Vaňousová

doi: 10.5431/aramit4901

Abstract. The zoological collection of the National Museum, Prague (NMP) contains spirit (juvenile) as well as dry (mostly adult) specimens of horseshoe crabs (Xiphosura). Living horseshoe crabs are of immunological importance due to clotting agents present in their hemolymph. Here we summarize basic data about the mechanism of the immune system of these marine animals and its use in practice – the *Limulus* Amebocyte Lysate test – including the laboratory assays and handling with the animals. In the NMP collection, 82 specimens (16 dry and 66 spirit) of all four currently recognised living species of horseshoe crabs are present. They were collected in Indonesia, USA and Vietnam in 1872–1998; *Limulus polyphemus* from the USA is the most numerous species in the NMP. The collection contains no type specimens but three historical mounted ontogenetic series are present. The largest part of the horseshoe crab collection is 55 spirit specimens from the collection of Václav Frič (1839–1916) whose preparations were intended mostly for educational purposes.

Keywords: identification key, LAL test, pharmacology, Václav Frič, Xiphosurida, zoological collection

Horseshoe crabs are marine bottom-dwellers, growing up to 85 cm long. Their prosoma is covered with a single unjointed carapace bearing two compound eyes. Research on the compound eyes of horseshoe crabs has led to a better understanding of human vision and based on their results, Ragnar Granit, Haldan Keffer Hartline and George Wald were awarded the Nobel Prize in Physiology or Medicine in 1967 (Nobel Media AB 2014). The opisthosoma bears paired movable lateral spins and an unpaired telson. There are four Recent species described: *Limulus polyphemus* (Linnaeus, 1758) from the North American East coast, and *Carcinoscorpius rotundicauda* (Latreille, 1802), *Tachypleus tridentatus* (Leach, 1819) and *Tachypleus gigas* (O. F. Müller, 1785) all from South-East Asia. All four species are similar in terms of ecology, life history and serology. They burrow through the surface layers of muddy substrate and ingest smaller animals or scavenge. The so-called trilobite larvae hatch from the eggs; the horseshoe crabs reaches maturity after 9–12 years and the life span may be up to 19 years. Males differ from females in having modified the first two pairs of walking legs into claspers used during mating. Horseshoe crabs occupy a crucial place in the food chain in coastal ecosystem – molluscs, crustaceans, fish, leopard sharks, eels, migratory shorebirds and sea turtles prey on horseshoe crabs during different stages of their life cycle (Shuster 1982, Keinath et al. 1987). Other features of their biology and ecology can be found in Sekiguchi (1988), Shuster et al. (2003) and Tanacredi et al. (2009).

History of the taxonomy of horseshoe crabs was summarized in Dunlop et al. (2012), their phylogenetic relationships were revealed by Obst et al. (2012) and their current taxonomical position was revised by Lamsdell (2013) as follows:
Subphylum: Chelicerata Heymons, 1901
Class: Xiphosura Latreille, 1802 (syn. Merostomata Dana, 1852)
Order: Xiphosurida Latreille, 1802
Family: Limulidae Leach, 1819

The diploid chromosome numbers (2n) of horseshoe crabs were published by Iwasaki et al. (1988). Recently, mitochondrial genome sizes (MGS) and a genome adenine-thymine base ratio (AT) of horseshoe crabs have been studied (Lavrov et al. 2000, Baek et al. 2014) resulting in the following genetic characteristics – *L. polyphemus*: 2n = 52, MGS = 14985 bp, AT = 67.6%; *C. rotundicauda*: 2n = 32, MGS = 15033 bp, AT = 73.8%, *T. tridentatus*: 2n = 26, MGS = 15006 bp, AT = 74.0%; *T. gigas*: 2n = 28, MGS and AT yet unknown. In addition to this, horseshoe crabs are of great clinical importance due to clotting agents present in their hemolymph as summarized below.

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submitted 27.11.2014, accepted 10.3.2015, online: 29.5.2015

Currently, many museums are publishing catalogues of their collections (e.g. Jiroušková et al. 2011, Chiarle et al. 2012, Dunlop et al. 2012, 2014, Kielhorn et al. 2012, Mlíkovský et al. 2013, Seiter & Hörweg 2013). Thus, the aim of this paper is to summarize the practical use of horseshoe crabs and to provide further information about the zoological collections of the National Museum in Prague.

The American horseshoe crab – a guardian of public health

The study of haematology using the horseshoe crab as a model is possible due to large blood cells (amebocytes) and led to discovery of the *Limulus* Amebocyte Lysate test (LAL test) by Bang & Forst (1953). They observed that infection by gram negative bacteria caused intravascular coagulation in the horseshoe crab. Coagulation is activated by the cascade of enzymes located in the amebocytes and is triggered by lipopolysaccharide (LPS, endotoxin) in the gram negative bacterial cell walls (Levin & Bang 1964a, 1964b, 1968). The catalytic nature of each activated enzyme in the coagulation cascade serves in turn to amplify the next step, resulting in a high sensitivity of LAL to LPS (Iwanaga 2007).

Content of microorganisms in the seawater can reach up to 10^6 bacteria/ml and 10^9 virus/ml of seawater (Ammerman et al. 1984). Therefore, the effective and robust innate immune system of horseshoe crabs is a prerequisite for their survival in this environment (Menzel et al. 2002, Tincu & Taylor 2004). It has been suggested that the clot formed through the activation of the cascades captures and immobilizes invading microorganisms; clot formation is triggered not only by an endotoxin released by Gram negative bacteria but also by (1,3)-β-D-glucan (Morita et al. 1981) which is mainly present in the cell walls of yeast and other fungi (Iwanaga 1993, 2002, Muta et al. 1995). Moreover, the clot formed as a result of activation by endotoxin or glucans provides wound control by preventing bleeding and forming a physical barrier against additional infection entry (John et al. 2010, Armstrong et al. 2013). Thus, the *Limulus* clotting system is thought to be critical for both haemostasis and the biological defence of this animal (Iwanaga 2007). This gelation reaction of *Limulus* amebocyte lysate has been widely employed as a rapid and simple method for endotoxin testing. How then do horseshoe crabs protect public health?

Endotoxin (LPS) is a part of the outer membrane of Gram-negative bacteria and is released during lysis of the cell or cell division. Most problems for the pharmaceutical industry are caused by non-pathogenic Gram-negative bacteria amply represented in aquatic environments. The high occurrence of endotoxin cannot be excluded even in sterile products, since endotoxin is able to withstand steam sterilization. Mild Gram-negative bacterial infections can trigger a pyrogenic response. The presence of endotoxin in the blood stream can cause fever, inflammation, and frequently irreversible shock (Joiner et al. 2002). Since humans are sensitive to minute amounts of endotoxin, the importance of testing for endotoxin is apparent.

In the early 1970s, a newer pyrogen testing technique using horseshoe crabs' blue copper-based blood was developed. The LAL test would be 100 times more sensitive than the rabbit testing methods used before (Novitsky 1984). Clot formation is initiated by pico- to nanograms of bacterial endotoxin (Mikkelsen 1988). Because of its superior reliability and simplicity (the test takes only one hour), the LAL test became an invaluable tool for the pharmaceutical industry. Every drug and medical device certified by the Food and Drug Administration must be tested by a LAL test (Walls & Berkson 2000).

The LAL test is employed to ensure that pharmaceutical products are endotoxin-free including bulk lot release testing, final product release testing and raw materials testing (Rudloe 1983). Anyone who has ever encountered intravenous fluids, vaccines or surgical implants has been protected against contact with bacterial endotoxin by the blue blood of a horseshoe crab. The LAL test is used not only to determinate harmful levels of endotoxin in pharmaceutical products, but is also the backbone of controlling endotoxin in both the process and equipment involved in producing pharmaceuticals and of monitoring high purity water used as a prime source. Furthermore, the LAL test is the method of choice for researchers examining the clinical or the environmental effects of endotoxin (Walls et al. 2002).

Currently, three principal LAL test methods exist; the gel clot, turbidimetric and chromogenic methods. The latter two are referred to as the photometric method for they require an optical reader. The gel clot assay is the simplest method of determining the level of bacterial endotoxin. In the assay, equal volumes of LAL reagents are mixed with the

tested sample and clot formation is observed. At the end of the incubation period the tube containing the mixture of the sample and LAL is inverted. If a gel has formed and remains intact in the bottom of the reaction tube after an inversion of 180 degrees (Fig. 1), the test is positive. A positive test indicates that the concentration of endotoxin in the tube is greater than or equal to the sensitivity of LAL (Associates of Cape Cod Inc. 2007a).

Both photometric methods require a standard curve to determine the endotoxin level in the sample. The chromogenic assay is based on replacing the natural substrate, coagulogen, by a chromogenic substrate. The chromogenic substrate is cleaved by the serine protease coagulose activated by endotoxin, and then the chromophore is released and is measured by spectrophotometry (Associates of Cape Cod Inc. 2011). The turbidimetric method is analogous to the chromogenic method, but the turbidity is monitored (Joiner et al. 2002).

In the blood of the horseshoe crab, other compounds of biomedical interest have also been discovered. LAL is used for detecting 1,3-β,D-glucans e.g. in pharmaceutical products or in a test for fungal infection (Obadasi et al. 2004, Associates of Cape Cod Inc. 2007b). Furthermore, an endotoxin-neutralizing protein which has potential as an antibiotic as well as an alternative endotoxin assay, and a number of other proteins that show anti-viral and anti-cancer activity are being explored (Valespi et al. 2000, Andrä et al. 2004, Tincu & Taylor 2004).

Fig. 1: The positive result of a gel clot assay (photograph provided by Biogenix, s. r. o., reprinted with permission)

Fig. 2: Bleeding of horseshoe crabs (photograph provided by Associates of Cape Cod Inc., reprinted with permission)

And how is the blood of the horseshoe crab obtained? Adult horseshoe crabs are collected by trawlers or by hand-harvest and transported to the lab of a biomedical company, where they are washed and placed on a rack. Horseshoe crabs are bled from pericardium with a large gauge needle – up to 30% of the animal's blood is removed (Fig. 2). Within 72 hours, the bled horseshoe crabs are returned to the place of capture and released alive (ASMFC 1998, Leschen & Correia 2010). Their blood volume restores in about a week. The amebocytes regenerate at a slower rate, requiring up to four months before cell counts equal to those obtained prior to bleeding (Novitsky 1984).

Mortality of horseshoe crabs after the bleeding process was found to be 3-15 % (Walls & Berkson 2000). There are currently five biomedical companies producing LAL in the United States. Each of them has unique bleeding methods, method of capture, distance and method of travel to bleeding lab, holding time and conditions, and methods of return most appropriate to their own setting and situation. Thus, the impact of the blood extraction processes on survival of the horseshoe crabs varies between operations (Walls et al. 2002).

The blood of horseshoe crabs can be extracted without killing the animals, but nowadays attention is paid to long-term injury caused by the bleeding process. Recent studies denote that the biomedical bleeding process potentially led to several sub-lethal behavioural and physiological changes. The most obvious behavioural effects are immediate decreases in walking speed and latent reductions in both overall activity and the expression of tidal rhythms. The greatest impact of bleeding on *Limulus* physiology is an immediate and sustained decline in hemocyanin concentrations (Anderson et al. 2013).

Horseshoe crab blood is not only a backbone of pharmaceutical industry, but it is also big business. On the world market, a quart of horseshoe crab blood has a price tag estimated at $15000, leading to overall revenues from the LAL industry estimated at U.S. $50 million per year. According to the Atlantic States Marine Fisheries Commission, that $50 million dollar industry requires the blood of approximately 500,000 horseshoe crabs (ASMFC 2013).

Fortunately, companies producing LAL realize that a stable population of horseshoe crab is essential not only for the pharmaceutical industry but also for survival of other marine animals that have a symbiotic relationship with the horseshoe crab. The LAL industry has taken steps to make the LAL test synthetically or to find methods to improve the sensitivity of LAL, which would eliminate the use of live horseshoe crabs for the LAL reagent (Thorne et al. 2010). With growing concern over declining populations, it is obvious that it will be a challenge to ensure that horseshoe crabs manage to fulfil all these diverse needs and at the same time to ensure their sustainable population for the future.

The situation is bit different in Asian horseshoe crabs. The *Tachypleus* Amebocyte Lysate (TAL) is derived from the two *Tachypleus* species – *T. tridentatus* and *T. gigas*. Nevertheless, only two species, *L. polyphemus* and *T. tridentatus* are mentioned in the European Pharmacopeia, the United States Pharmacopeia and in the Japanese Pharmacopeia. In Asia, TAL is manufactured in China and Japan (Wang et al. 2007). However, most of the animals used come from areas in Southeast Asia where harvesting regulations have not been established or enforced and less is known regarding their horseshoe crab collection and handling practices. It is believed that most horseshoe crabs die post-bleeding, some as bait, some as food, and some due to the bleeding process itself.

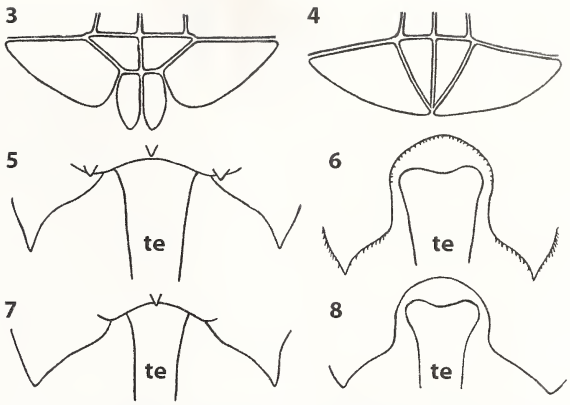
Material and methods

Methods for curating the horseshoe crab collection followed those of Dunlop et al. (2012). Specimens were determined by the key provided below that was composed based on characteristics published by Yamasaki (1988), Shuster & Anderson (2003) and Dunlop et al. (2012). Current nomenclature and the Life Science Identifier numbers (lsid) were adopted from WoRMS (2014). The items belonging to one species are sorted chronologically from the oldest to the newest one. Data for each item are arranged as follows: inventory number under the acronym NMP (National Museum Prague), number of specimens and their sex (type of preparation), name of the collector, date of collection, locality – the current name of the locality was adopted from NGA (2014); note if any. In dry material, total length (TL) and carapace width (CW) is provided. If the telson is missing or broken, only CW is noted.

Identification key for living species

1) A pair of finger-like projections on the genital operculum (Fig. 3); the first entapophyseal pit on opisthosoma triangulate (left ┌, right ┐); telson shorter than the body; distributed in the western Atlantic along the eastern seaboard of North-Central America ..... *Limulus polyphemus*
– No finger-like projections on the genital operculum (Fig. 4); the first entapophyseal pit on opisthosoma elongate (ı); telson at least as long as the body; distributed in the Indo-Pacific waters of South-East Asia ..... Tachypleinae (2)
2) Telson longer than the body, smooth, rounded in profile (without any ventral groove or dorsal keel); all opisthosomal marginal spines short (Fig. 12); total length up to 35 cm in males and 40 cm in females ..... *Carcinoscorpius rotundicauda*
– Telson as long as the body, triangular in profile (usually with a ventral groove and dorsal keel); the first three (in females) or all (in males) opisthosomal marginal spines long; usually larger animals ..... *Tachypleus* (3)
3) Total length 45-70 cm in males and 55-85 cm in females; mid-dorsal part of opisthosomal posterior margin with three short immovable spines pointing posteriorly (Fig. 5); anal angles (from ventral view) with thorn-like spines on both outer lateral margins (Fig. 6); males with a pair of strong indentations to the anterior rim of the prosoma (Fig. 13) ..... *T. tridentatus*

– Total length 25-40 cm in males and 25-50 cm in females; mid-dorsal part of opisthosomal posterior margin with one short immovable spine pointed posteriorly and with no spines on either side (Fig. 7); anal angles (from ventral view) usually with smooth outer lateral margins (although they rarely have small spines on the margin) (Fig. 8); males with smooth margins of the anterior rim of the prosoma (Fig. 14) ..... *T. gigas*



Figs 3-8: Diagnostic characters of horseshoe crabs. **3:** *Limulus polyphemus*, a pair of finger-like projections on the genital operculum; **4:** Asian horseshoe crabs, no finger-like projections on the genital operculum; **5:** *Tachypleus tridentatus*, mid-dorsal part of opisthosomal posterior margin with three short immovable spines pointed posteriorly; **6:** *T. tridentatus*, anal angles (from ventral view) with thorn-like spines on both outer lateral margins; **7:** *Tachypleus gigas*, mid-dorsal part of opisthosomal posterior margin with one short immovable spine pointed posteriorly and with no spines on either side; **8:** *T. gigas*, anal angles (from ventral view) with smooth outer lateral margins; te = telson

Systematic list
Subfamily: Limulinae Leach, 1819
Genus: *Limulus* O. F. Müller, 1785

Limulus polyphemus (Linnaeus, 1758)
urn:lsid:marinespecies.org:taxname:150514
NMP P6E-2460, 1 ♂ (dry material, TL = 38 cm, CW = 20 cm), collected by Dr. Palacký in 1872 in North America.

NMP 19/1960/2564, 6 juveniles (spirit material), collected by an unknown collector in 1886 in Woods Hole (41°31'25"N 70°40'20"W), USA; ex. coll. V. Frič.

NMP 19/1960/2745, 30 juveniles (spirit material), collected by an unknown collector in 1886 in Woods Hole (41°31'25"N 70°40'20"W), USA; ex. coll. V. Frič.

NMP P6E-3903, mounted ontogenetic series containing 18 eggs and 4 juveniles (spirit material), donated by A. S. Packard to J. Barrande from whose inheritance it arrived in the NMP in 1894; Fig. 9.

NMP P6E-2462, mounted ontogenetic series containing 4 eggs and 6 juveniles (spirit material), collected by an unknown collector on 24 September 1896 in New York, Long Island (40°37'00"N 73°50'20"W), USA; Fig. 10.

NMP 19/1960/2580, 7 juveniles (spirit material), collected by Brimley Bros Raleigh in February 1904 in USA; ex. coll. V. Frič.

NMP 19/1960/2905, 1 juvenile (spirit material), collected by an unknown collector on 25 January 1913 in Woods Hole (41°31'25"N 70°40'20"W), USA; ex. coll. V. Frič.

NMP P6E-2461, 1 ♀ (dry material, TL = 56 cm, CW = 27 cm), collected by an unknown collector in 1913 in North America; ex. coll. V. Frič.

NMP 19/1960/2280, 1 juvenile (spirit material), unknown origin; ex. coll. V. Frič.

NMP 19/1960/2281, 1 trilobite larva (spirit material), unknown origin; ex. coll. V. Frič.

NMP 19/1960/3100, mounted ontogenetic series containing 4 eggs and 9 juveniles (spirit material), unknown origin; ex. coll. V. Frič; Fig. 11.

NMP P6d-8/2003, 1 malformed ♀ with broken telson (dry material, CW = 29 cm) and 1 ♂ (dry material, TL = 39 cm, CW = 19 cm), unknown origin.

NMP P6d-254/2003, 1 female carapace (dry material, TL = 61 cm, CW = 29 cm), collected by Mr. Morawitz in 1957 in New York, Long Island (40°37'00"N 73°50'20"W), USA.

NMP P6E-2794, 1 ♀ and 2 juveniles (dry material, TL = 37, 4 and 3 cm, CW = 18, 2 and 2 cm), collected by D. Collins in 1968 in Naples, Florida (26°08'30"N 81°48'30"W), USA.

Other material: 1 ♂ in poor condition (dry material, TL = 38 cm, CW = 21 cm) and 2 damaged (probably female and male) carapaces (dry material, TL = ? and 39 cm, CW = 25 and 19 cm), unknown origin; packed in a newspaper "Národní politika" [National politics] from 22 March 1929.

9 10

Fig. 9: Mounted ontogenetic series of *Limulus polyphemus* (NMP P6E-3903), inheritance of J. Barrande
Fig. 10: Mounted ontogenetic series of *Limulus polyphemus* (NMP P6E-2462), from the former zoological exhibition

Subfamily: Tachypleinae Pocock, 1902
Genus: *Carcinoscorpius* Pocock, 1902

Carcinoscorpius rotundicauda (Latreille, 1802)
urn:lsid:marinespecies.org:taxname:238267
NMP P6E-3085, 1 ♂ (dry material, TL = 33 cm, CW = 15 cm), collected by J. Wünsch in May 1973 in Tuần Châu, Vịnh Hạ Long (20°55'40"N 106°59'40"E), VIETNAM; Fig. 12.

Genus: *Tachypleus* Leach, 1819

Tachypleus tridentatus (Leach, 1819)
urn:lsid:marinespecies.org:taxname:238270
NMP P6E-2838, 1 ♂ (dry material, TL = 60 cm, CW = 28 cm), collected by Dr. Hložánek in 1988 in VIETNAM; Fig. 13.

NMP P6E-3086, 1 young ♀ (dry material, TL = 61 cm, CW = 32 cm), collected by K. Vopařil in 1998 in VIETNAM; originally labelled as "*Limulus grandis*".

Tachypleus gigas (O. F. Müller, 1785)
urn:lsid:marinespecies.org:taxname:238271
NMP P6E-3904, 1 juvenile (spirit material), collected by an unknown collector in 1898 in Maluku (3°50'S 129°50'E), INDONESIA; originally labelled as *Limulus moluccanus*.

NMP P6E-3120, 1 ♀ (dry material, TL = 40 cm, CW = 19 cm), collected by Dr. Jerman on 17 December 1933 in Gunung Pantaicarmin, Sumatera Barat (1°22'60"S 100°34'30"E), INDONESIA.

NMP P6E-3121, 1 ♂ (dry material, TL = 31 cm, CW = 15 cm), collected by Dr. Jerman on 11 No-

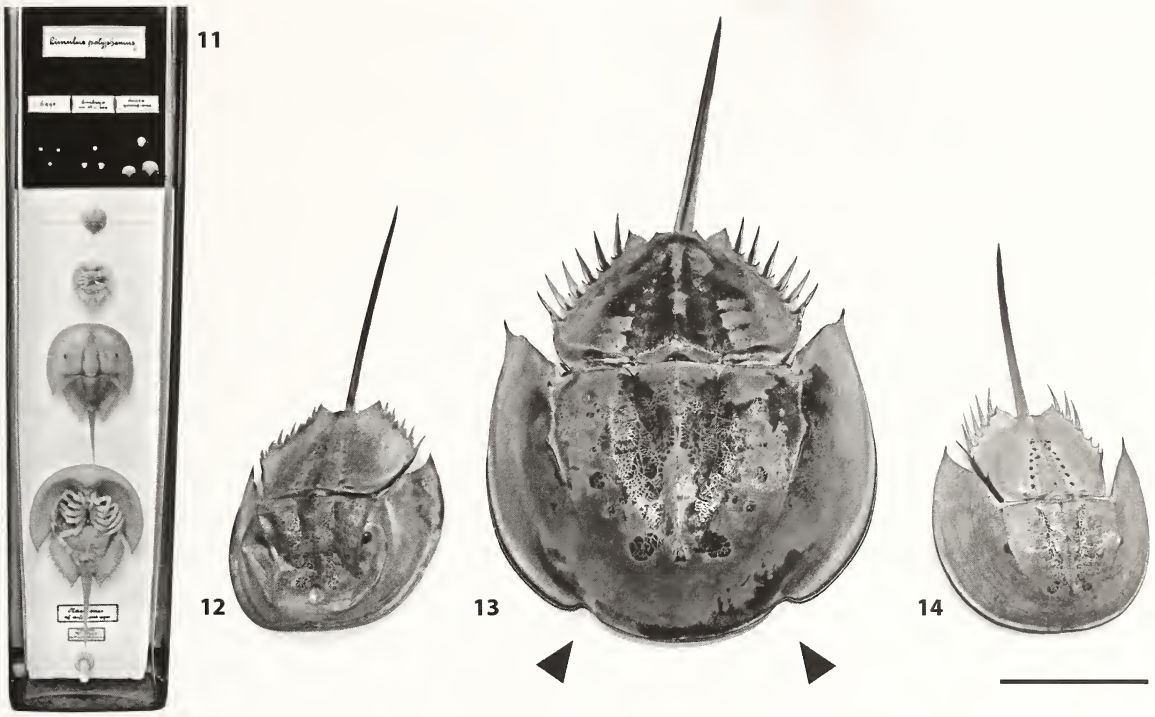


Fig. 11: Mounted ontogenetic series of *Limulus polyphemus* (NMP 19/1960/3100), ex. coll. V. Frič
Figs 12-14: Males of horseshoe crabs in relation to one another. **12:** *Carcinoscorpius rotundicauda* (NMP P6E-3085), note short opisthosomal movable marginal spines; **13:** *Tachypleus tridentatus* (NMP P6E-2838), note a pair of strong indentations to the anterior rim of the prosoma (arrowheads); **14:** *Tachypleus gigas* (NMP P6E-3121), note smooth margins of the anterior rim of the prosoma; scale bar = 10 cm

vember 1934 in Gunung Pantaicarmin, Sumatera Barat (1°22'60"S 100°34'30"E), INDONESIA; Fig. 14.

Acknowledgements
We would like to thank Jason A. Dunlop (Museum für Naturkunde, Berlin) for supplying us with important literature, grammar corrections and useful comments to the manuscript. We also thank Michaela Zemánková (Biogenix, s. r. o., Prague) and Veronika Wills (Associates of Cape Cod, Inc., East Falmouth) for permission to use the figures. This work was financially supported by Ministry of Culture of the Czech Republic (DKRVO 2014/14, National Museum, 00023272).

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A new species of *Euscorpius* (Scorpiones: Euscorpiidae) from southern Bulgaria

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doi: 10.5431/aramit4902

Abstract. A new scorpion species, *Euscorpius drenskii* **sp. nov.**, is described from the Western Rhodope Mts. in southern Bulgaria. It is characterized by an oligotrichous trichobothrial pattern, which shows a conspicuous loss of one trichobothrium in the external median patellar series (*em* = 3), also observed in *E. carpathicus* (Linnaeus, 1767) and the subgenus *Alpiscorpius* Gantenbein, Fet, Largiadèr & Scholl, 1999. Phylogenetic analysis of 16S rDNA marker sequences does not show any close relationship between these three groups, suggesting that the observed loss of a trichobothrium is an independent event.

Keywords: Scorpions, systematics, West Rhodope, 16S rDNA

The genus *Euscorpius* Thorell, 1876, widespread in southern Europe and Anatolia, is one of the most studied scorpion taxa. Despite this, the taxonomy of this genus is very complicated and still far from being resolved. This is also true for Bulgaria, where this genus has been insufficiently studied in the past. Taxonomic studies of *Euscorpius* are further hindered by the existence of cryptic species complexes, difficult to resolve even with phylogenetic analyses (Parmakelis et al. 2013, Tropea et al. 2014a). Several relatively recent studies have provided information on different *Euscorpius* populations from Bulgaria, assuming the possibility of new species (Valle 1975, Fet 2000, Teruel et al. 2004, Fet & Soleglad 2007). However, they did not focus on resolving the systematic position of these forms, but rather grouped different populations based on a few morphological characteristics, and placed them in the following species complexes: "*E. carpathicus* complex", "*E. hadzii* complex" and "*E. mingrelicus* complex". Most recently, Fet et al. (2014) described two new species based on molecular and morphological evidence from northern and southwestern Bulgaria: *E. deltshevi* and *E solegladi*.

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Here, we describe a new species from Rhodope Mts. in southern Bulgaria, *E. drenskii* **sp. nov.**, based on morphological and molecular evidence analyses.

Methods and material

The trichobothrial notation follows Vachon (1974). Morphological measurements are given in millimeters (mm) following Tropea et al. (2014b). Morphological nomenclature follows Stahnke (1970), Hjelle (1990) and Sissom (1990); the chela carinae and denticle configuration follows Soleglad & Sissom (2001); and sternum terminology follows Soleglad & Fet (2003). The map was generated by Earth Explorer 6.1, with positional and altitude data compiled through Google Maps.

All DNA work was performed in the University of Athens by PK and AP; for details on DNA extraction, amplification and sequencing, see Parmakelis et al. (2013). Phylogenetic analysis was conducted by GT as specified below. Nomenclature for reporting DNA sequences from non-type ("geneseq-3") specimens follows Chakrabarty et al. (2013).

Abbreviations

V: trichobothrial series on pedipalp chela manus ventral surface (not including Et_1); *Pv*: trichobothria on the ventral aspect of pedipalp patella; *Pe*: trichobothria on the external surface of pedipalp patella; *et*: external terminal; *est*: external subterminal; *em*: external median; *esb*: external suprabasal; eb_a: external basal-*a*; *eb*: external basal; *db*: dorsal basal trichobothrium on fixed finger; *Dp*: pectinal teeth number; *L*: length; *H*: height; *Lchel*: chela length; *Wchel:* chela width (=*Wchel-A* of Tropea et al. 2014a); *Lcar*: carapace length; *Wcar*: carapace width; *Lfem*: femur

length; *Lpat*: patella length; *Lmet*: sum of the length of all metasomal segments; *Wmet:* sum of the width of all metasomal segments; *met.seg*: metasomal segment; *CarA/CarP %*: average ratio of distances from center of median eyes to anterior and posterior margins of the carapace; *DPS*: dorsal patellar spur; *DD*: distal denticle; *MD*: median denticles; *OD*: outer denticles; *ID*: inner denticles; *IAD*: inner accessory denticles; *imm.*: immature specimen (in any stage of development).

Depositories. GTC, personal collection of Gioele Tropea, Rome, Italy; MSNB, Museo Civico di Scienze Naturali "E. Caffi", Bergamo, Italy; MZUR, Museo di Zoologia dell'Università di Roma "Sapienza", Rome, Italy; NMNHS, National Museum of Natural History, Sofia, Bulgaria; VFPC: personal collection of Victor Fet, Huntington, West Virginia, USA; ZMMSU, Zoological Museum of Moscow State University, Moscow, Russia.

Material studied. A detailed list of material with label data is provided below.

Phylogenetic analysis

A new *16S rDNA* sequence for *Euscorpius drenskii* (West Rhodope Mts., Smolyan Province, Trigrad, 41.60°N, 24.38°E, 1474 m, 31 May 1999, leg. V. Fet & V. Sakalian; geneseq-3 16S) was deposited in GenBank under a submission number KP12342. Twelve published mitochondrial *16S rDNA* sequences have been retrieved from GenBank and used for comparison: *E. tergestinus* (C.L. Koch, 1837): AJ298066; *E. avcii* Tropea, 2012: KF030937; *E. carpathicus* (Linnaeus, 1767): AY172338; *E. concinnus* (C.L. Koch, 1837): DQ989935; *E. flavicaudis* (De Geer, 1778): DQ989957; *E. germanus* (C.L. Koch, 1837): AJ249553; *E. italicus* (Herbst, 1800): DQ989956; *E. stahlavskyi* Tropea , 2014: KC215605; *Euscorpius* sp.: KC215579; KC215580; KC215651; KC215644 (Gantenbein et al. 2001, Huber et al. 2001, Fet et al. 2002, Salomone et al. 2007, Parmakelis et al. 2013). The 13 sequences were aligned by eye. Phylogenetic analyses were conducted in MEGA5 (Tamura et al. 2011). All positions containing gaps and missing data were eliminated. There were a total of 366 positions in the final dataset. The phylogeny (Fig. 21) was inferred using the Neighbor-Joining algorithm (Saitou & Nei 1987); the optimal tree with the sum of branch length = 0.41174926 is shown, indicating the bootstrap values (1000 replicates) next to the clades (Felsenstein 1985). The tree is drawn to scale, with branch lengths in the same units as the genetic distances. The genetic distances (Tab. 2) were computed using the Kimura 2-parameter method of Kimura (1980) and are expressed as the number of base substitutions per site.

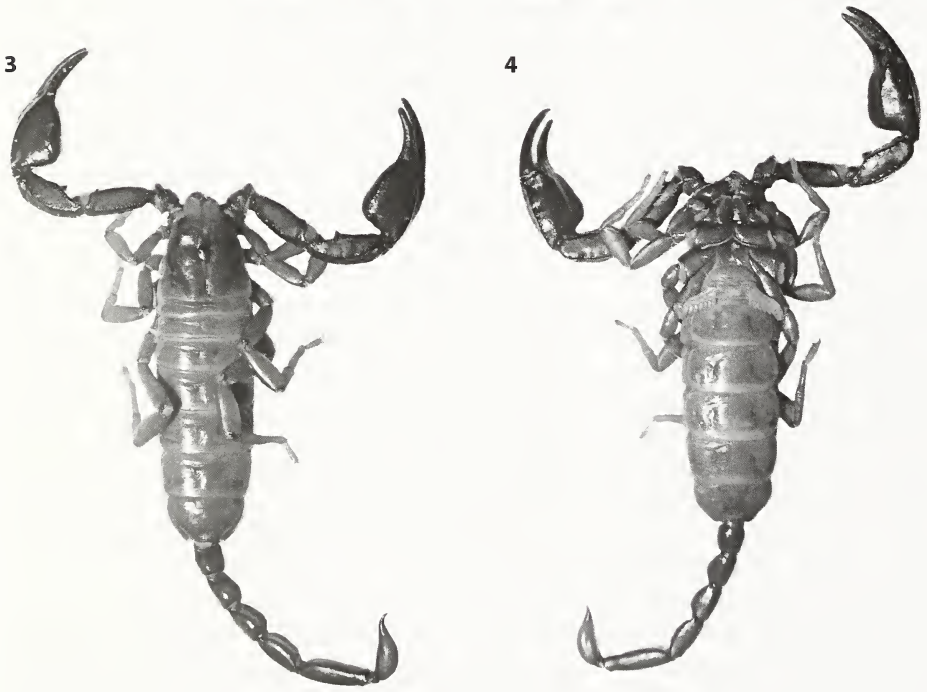
History of study

The remote West Rhodope Mts. escaped early scorpion scholars, although the very first specimen deposited in the National Museum of Natural History, Sofia, Bulgaria (NMNHS) was collected as early as 1901 by Prince Ferdinand, the founder of this important Museum in 1889. Ferdinand I (1861–1948) of Saxe-Coburg-Gotha royalty, the Knyaz (Prince Regnant) of the independent Bulgaria since 1887, and its Tsar (King) since 1908, was an amateur lepidopterist and botanist, who promoted natural science in the Balkans.

Even though additional specimens from the West Rhodopes were collected by the most prominent Bulgarian arachnologist Pencho Drenski in 1924–1925, they have not been studied or published. The Bulgarian populations were overlooked in the most comprehensive revision of *Euscorpius* (Di Caporiacco 1950). The first data on *Euscorpius* from the West Rhodope was published by Valle (1975) who studied specimens from Smolyan Province (which currently cannot be found in the important Valle collection at Museo Civico di Scienze Naturali "Enrico Caffi", Bergamo). Trichobothrial values given by Valle (1975) as B2 = 6 and B3 = 8 correspond to standard values (Vachon 1974) as *eb* = 4/4 and eb_a = 4/4; see Fet et al. (2003: 374) for a detailed scheme comparing Valle's and Vachon's systems of trichobothrial notation. Valle, however, did not report *em* number (D4 series) for his Smolyan specimens.

Independently, 16 specimens from the West Rhodope Mts. (now in ZMMSU) were donated to V.F. in 1984 by Dr. Christo Deltshev. This series was collected by the late Dimitar Raichev, an amateur naturalist of Chepelare, Smolyan Province, in 1981–1983. This enigmatic population was studied by V.F. and triggered his first interest in Bulgarian scorpions. Specimens were first reported as having *em* = 3 by Fet (1993); it was clear already at that time that the Smolyan specimens do not belong to the standard Balkan "*E. mingrelicus* complex" with its et-est / est-dsb trichobothrial fixed finger ratio > 1.5; this ratio was on average only about 1.02 in the Raichev speci-

Figs 1-2: *Euscorpius drenskii* sp. n., male holotype
1. Dorsal view
2. Ventral view



Figs 3-4: *Euscorpius drenskii* sp. n., female paratype
3. Dorsal view
4. Ventral view

men series (Fet, pers. obs.). However, the species was then erroneously interpreted as *E. croaticus* (Fet 1993, Fet & Braunwalder 2000; see below for details).

Fet & Soleglad (2002) noted that an unnamed form with *em* = 3 is found in the Rhodope Mountains of Bulgaria. Later, Fet & Soleglad (2007) provided the first comprehensive analysis of Bulgarian scorpion fauna, where the new species described herein was treated under "*E. carpathicus* complex". The first DNA phylogeny from Greece and adjacent regions of the Balkans published by Parmakelis et al. (2013) indicated that *Euscorpius* fauna of the Rhodope Mountains in both Greece and Bulgaria belongs to an undescribed, basal species complex (subgenus incertae sedis).

The diverse scorpion fauna of the Rhodopes and adjacent mountain ranges is an expected feature since this region is known for high, ancient diversity of faunal elements (for detailed reviews on biogeography of many groups of vertebrates and invertebrates, see Fet & Popov 2007).

Systematics

Genus ***Euscorpius*** Thorell, 1876

Subgenus incertus

Euscorpius drenskii Tropea, Fet, Parmakelis, Kotsakiozi & Stathi, **sp. nov.**
(Figs 1-20, Tabs 1-2)

Euscorpius carpathicus: Valle 1975: 232 (in part; Bulgaria: Smolyan Province).
Euscorpius germanus croaticus: Fet 1993: 5 (in part; Bulgaria); Fet & Braunwalder 2000: 20 (in part; Bulgaria: Smolyan Province).
Euscorpius carpathicus "Group C": Fet 2000: 55 (in part; Bulgaria: Smolyan Province); Fet & Soleglad 2002: 4.
Euscorpius cf. *carpathicus* "Rhodope group": Fet & Soleglad 2007: 415, fig. 15 (in part; Bulgaria: Smolyan Province).

Type material (12 specimens: 6 ♂, 6 ♀)
Holotype: ♂, BULGARIA, West Rhodope Mts.: Smolyan Province, Shiroka Laka, 25 June 1924, leg. P. Drenski (NMHNS 275). ***Paratypes***: 1 ♂, 1 ♀, West Rhodope Mts., Smolyan Province, Shiroka Laka, 25 June 1924, leg. P. Drenski (NMHNS 275); same data, 2 ♂, 1 ♀ (MZUR); same data, 1 ♂, 1 ♀ (MSNB); 3 ♀ (of which 1 imm.); West Rhodope Mts., Smolyan Province, Devin District, Trigrad, 25 June 1924, leg. P. Drenski (NMHNS 301); 1♂, West Rhodope Mts., Smolyan Province, Shiroka Laka, 26 June 1924, leg. P. Drenski (NMHNS 310).

Other *E. drenskii* sp. nov. examined (not included in type series): (31 specimens: 7 ♂, 24 ♀).
BULGARIA, West Rhodope Mts.: Smolyan Province, May 1901, leg. Prince Ferdinand, 1 ♀ (NMNHS 280); Smolyan Province, Devin District, 1981–1983, leg. D. Raichev, 2 ♂, 11 ♀ (ZMMSU), Smolyan Province, Devin District, Hizha Orfei ("Orpheus Hut"), 16 June 1983, leg. D. Raichev, 1 ♂, 1 ♀ (ZMMSU);

Tab. 1: Measurements (mm) and morphometric ratios of *Euscorpius drenskii* **sp. n.**

		Holotype ♂	Paratype ♀
Total	Length	28.14	28.59
Carapace	Length	3.96	6.95
	Post. width	4.08	4.32
Metasoma	Length	11.28	10.14
Segment I	Length	1.44	1.32
	Width	1.47	1.47
Segment II	Length	1.74	1.62
	Width	1.32	1.29
Segment III	Length	1.98	1.80
	Width	1.26	1.23
Segment IV	Length	2.34	1.92
	Width	1.20	1.14
Segment V	Length	3.78	3.48
	Width	1.20	1.14
Telson	Length	3.90	3.36
Vesicle	Length	2.82	2.22
	Width	1.56	1.08
	Height	1.59	1.14
Aculeus	Length	1.08	1.14
Femur	Length	3.36	3.48
	Width	1.32	1.32
Patella	Length	3.39	3.60
	Width	1.44	1.56
Chela	Length	7.02	7.02
	Width	2.76	2.55
Movable finger	Length	4.08	3.96
Ratio	*CarA (%)*	40.91	41.72
	Lcar/Lfer	1.178	1.198
	Lcar/Ltel	1.015	1.241
	Lchel/Wchel	2.543	2.753
	L/W met.seg I	0.979	0.894
	L/W met.seg II	1.318	1.256
	L/W met.seg III	1.571	1.463
	L/W met.seg IV	1.950	1.684
	L/W met.seg V	3.150	3.052
	Lmet/met.seg V	2.984	2.914
	Lmet/Lcar	2.892	2.431
	Lfem/Lpat	0.991	0.966

Figs 5–18: *Euscorpius drenskii* sp. n. **5.** Carapace. **6.** External view of the chela of adult male. **7.** External view of the chela of adult female. **8.** Dorsal view of pedipalp patella. **9.** Ventral view of pedipalp patella. **10.** External view of pedipalp patella. **11.** Dorsal view of pedipalp femur. **12.** Ventral view of pedipalp femur. **13.** Ventral view of the chela. **14.** Dorsal view of the chela. **15.** Telson of adult male. **16.** Telson of adult female. **17.** Ventral view of the metasomal segment V. **18.** Lateral view of the metasomal segment V

Smolyan Province, Devin District, Yagodinska Cave, entrance, 1981, leg. D. Raichev, 1 ♂ (ZMMSU); Smolyan Province, Devin District, Yagodina, 20 May 1983, leg. P. Beron, 3 ♀ (of which 1 imm.) (NMHNS 517); Smolyan Province, Rozhen Pass, 1500 m, in moss, 23 January 1997, leg. D. Raichev, 1 ♀ (NMHNS 221); Smolyan Province, Devin District, Trigrad, Trigradski Skali Hut, 6 August 1997, leg. B. Petrov, 1 ♀ imm. (NMHNS 200); Smolyan Province, Devin District, Trigrad, 1474 m, 41.60N, 24.38E, 31 May 1999, leg. V. Fet & V. Sakalian, 3 ♂ (of which 1 imm.), 2 ♀ (of which 1 imm.) (VFPC), 1 ♂, 1 ♀ (GTC); Smolyan Province, Devin District, between Mihalkovo and Devin, 550–700 m, 1–2 September 2001, leg. B. Petrov & V. Beshkov, 2 ♀ (NMNHS 198).

Fig. 19: *Euscorpius drenskii* sp. n., male holotype, ventral view of leg tarsus

Etymology. Named after the famous Bulgarian arachnologist Pencho Drenski (1886–1963) who collected the type specimens.

Geographic range. Bulgaria (south), West Rhodope Mts. (Fig. 20).

Diagnosis. A medium-small *Euscorpius* species, total length 28–31 mm. Colour of adults light to medium brown/reddish, carapace darker. Reticulation or marbling varies from absent to highly marked on chelicerae, carapace, mesosoma and metasoma. The number of

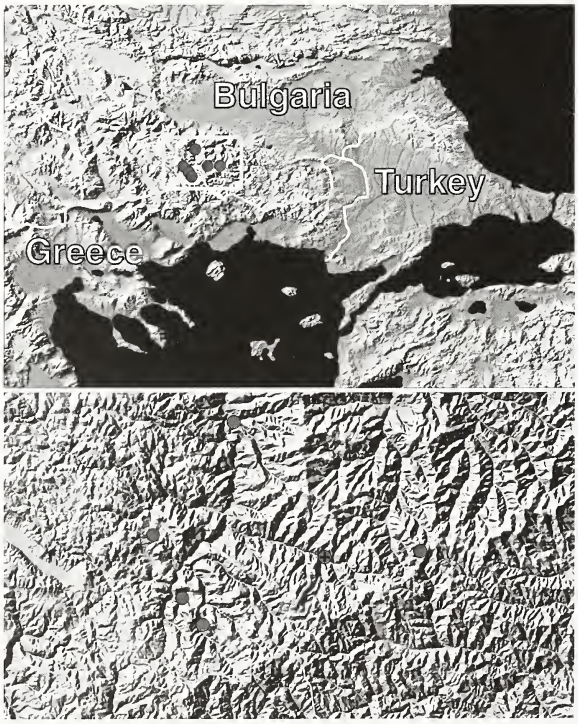


Fig. 20: Map showing type locality (+) and known distribution of *Euscorpius drenskii* sp. n.

Table 2. Genetic distances between 16S rDNA sequences.
The number of base substitutions per site between 13 sequences are shown. Standard error estimates are shown in the last column. See Methods and Material for explanations.

	1	2	3	4	5	6	7	8	9	10	11	12	13
1 *E.* sp. 120F	–	0.011	0.013	0.009	0.015	0.014	0.013	0.013	0.015	0.019	0.019	0.020	0.013
2 *E.* sp. FESP9	0.037	–	0.011	0.009	0.015	0.014	0.014	0.014	0.016	0.019	0.019	0.020	0.011
3 *E.* sp. FESP21	0.055	0.043	–	0.010	0.015	0.016	0.014	0.013	0.017	0.019	0.019	0.021	0.010
4 *E.* sp. 113F	0.025	0.028	0.034	–	0.014	0.013	0.013	0.013	0.015	0.018	0.018	0.020	0.010
5 *E. concinnus*	0.081	0.085	0.091	0.075	–	0.009	0.010	0.012	0.017	0.017	0.016	0.020	0.016
6 *E. tergestinus*	0.066	0.075	0.088	0.066	0.031	–	0.009	0.012	0.015	0.018	0.016	0.019	0.015
7 *E. carpathicus*	0.060	0.069	0.075	0.060	0.034	0.031	–	0.010	0.015	0.016	0.015	0.018	0.015
8 *E. italicus*	0.060	0.072	0.072	0.063	0.051	0.045	0.039	–	0.015	0.016	0.015	0.017	0.015
9 *E. avcii*	0.075	0.087	0.096	0.078	0.099	0.081	0.078	0.078	–	0.020	0.018	0.018	0.017
10 *E. stahlavskyi*	0.107	0.110	0.110	0.100	0.100	0.101	0.088	0.085	0.119	–	0.018	0.020	0.018
11 *E. germanus*	0.120	0.123	0.123	0.113	0.084	0.087	0.081	0.081	0.104	0.104	–	0.018	0.018
12 *E. flavicaudis*	0.129	0.135	0.142	0.132	0.119	0.110	0.103	0.093	0.109	0.123	0.100	–	0.021
13 *E. drenskii* sp.n.	0.055	0.043	0.037	0.034	0.094	0.084	0.078	0.081	0.090	0.103	0.119	0.142	–

trichobothria on the pedipalp manus ventral surface is 4 (V_{1-3} + Et_1). The number of trichobothria on the pedipalp patella ventral surface usually is 6. The number of trichobothria on pedipalp patella external surface is: *eb* = 4, eb_a = 4, *esb* = 2, *em* = 3, *est* = 4, *et* = 5. The pectinal teeth number in males usually is 8, more rarely 9; in females usually 7, more rarely 8. *Lchel/Wchel* ratio is 2.60 in males and 2.70 in females. Dorsal patellar spur well-developed. Femur usually more or less as long as patella; *Lfem/Lpat* ratio is 0.98. Carapace more or less as long as wide; average ratio *Lcar/Wcar* 1.015 in males and 0.967 in females; average distance from center of median eyes to anterior margin of the carapace is 40.82 % of the carapace length. Average ratio of *Lmet/Lcar* is 2.81 in males and 2.47 in females.

Trichobothrial and pectinal teeth count variation

The variation observed in 43 studied specimens (13 ♂, 30 ♀) is given below.

Pectinal teeth in males (n = 13): 7/8 (1), 8/8 (5), 8/9 (2), 9/8 (3), 9/9 (2); in total, 7 in 3.85 % (1), 8 in 61.54 % (16), and 9 in 34.62 % (9); mean = 8.31, SD = 0.55.

Pectinal teeth in females (n = 30): ?/? (1), 6/7 (2), 7/6 (1), 7/7 (22), 7/8 (3), 8/7 (1); in total, 6 in 5.17 % (3), 7 in 87.93 % (51) and 8 in 6.90 % (4); mean = 7.02, SD = 0.35.

Pedipalp patella trichobothria Pv (n = 43): 6/5 (1), 6/6 (37), 6/7 (1), 7/6 (2), 6/8 (1), 7/7 (1), 8/8 (1); in total, 5 in 1.16 % (1), 6 in 89.54 % (77) %, 7 in 5.81 % (5), and 8 in 3.49 % (3); mean = 6.12, SD = 0.45.

Pedipalp patella trichobothria Pe (n = 43): *et* = 4/4 (1), 4/5 (2), 5/5 (37), 5/6 (1), 6/5 (2); in total, 4 in 3.49 % (3), 5 in 93.02 % (80) and 6 in 3.49 % (3); mean = 5.00, SD = 0.27; *em* = 3/4 (1), 3/3 (42); in total, 3 in 98.84 % (85) and 4 in 1.16 % (only in 1 pedipalp); mean = 3.01, SD = 0.11; in all specimens, *est* = 4/4; *esb* = 2/2; eb_a = 4/4; *eb* = 4/4.

In addition, *et-est / est-dsb* ratio was measured in 16 pedipalps (of 16 different specimens): mean = 1.02, SD=0.14.

Hemispermatophore. Both right and left hemispermatophores of five specimens were studied. They have a well-developed lamina tapered distally; well-developed basal constriction present; truncal flexure present; median projection with primary and secondary acuminate processes, of which the secondary acuminate process is usually formed by a main tine, shaped as an elongated sickle, and from one to four secondary tines, which are more squat, and often forked with two or more tines; internal projection distally with 5–7 tines in its crown. The number and the shape of tines of the crown and of the seconda-

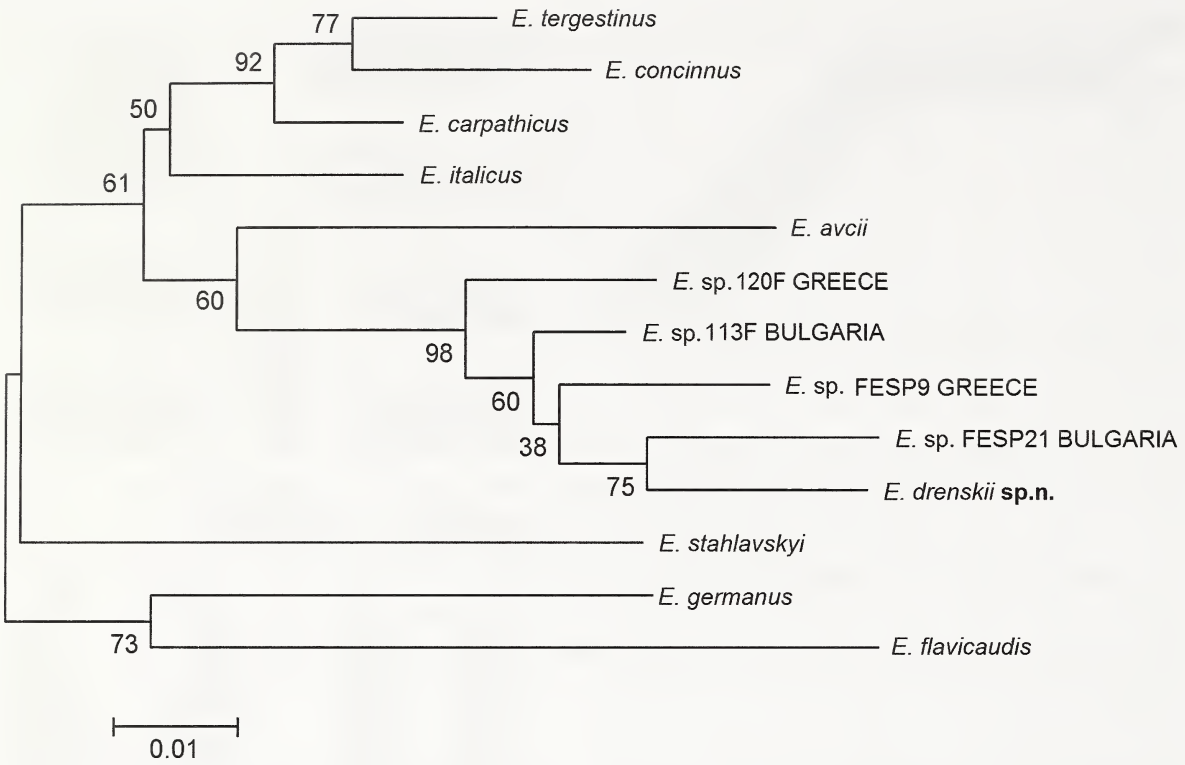


Fig. 21: A phylogenetic tree of *Euscorpius* based on *16S rRNA* mtDNA marker. See Methods and material for explanations.

ry acuminate process varied between specimens and between the right and the left hemispermatophores.

Description of the male holotype

Colouration: Whole colour light brownish with carapace and pedipalps darker reddish; sternites and pectines and genital operculum very light brownish/ivory; chelicerae very light, yellowish, palms without marbling; telson yellowish, with a longitudinal lighter line and dark reddish aculeus tip; all pedipalps carinae darker, dark brown to blackish coloured; none marbling is present.

Carapace: A very fine granulation on whole surface is present, except in the anterior area between the anterior edge, the lateral eyes and median eyes, which is almost smooth, very finely punctated and glossy, and the lateral area behind the lateral eyes, which has a few greater granules; anterior edge granulate and more or less straight; deep and dark posterior lateral furrows; two pairs of lateral eyes (with a larger anterior eye), and a pair of median eyes, situated distally of the middle; distance from centre of median eyes to anterior margin is 40.91 % of carapace length.

Mesosoma: Tergites very finely granulated; sternites glossy and punctated. Small spiracles inclined about 45° downward towards outside.

Metasoma: Dorsal carinae on segments I–IV with spaced weakly marked granules; ventrolateral carinae absent on segment I, obsolete or smooth on segments II–IV, granulated to serrulated on segment V; ventromedian carina absent on segments I–IV, the V with spaced weakly marked granules; dorsal intercarinal spaces with a very fine granulation, smooth on the lateral and ventral surface.

Telson: Vesicle smooth, with ventral setae of different size, especially near the vesicle/aculeus juncture.

Pectines: Teeth number 8/8; middle lamellae number 6/6; several microsetae on proximal area of teeth, marginal lamellae, middle lamellae and fulcra.

Genital operculum: The genital operculum is formed by two longitudinally separated subtriangular sclerites; genital papillae protruding; a few microsetae are present.

Sternum: Pentagonal shape, type 2; more or less as long as wide, with a deep posterior emargination.

***Pedipalps*:** Coxa and trochanter with tuberculated carinae. Femur: dorsal and ventral internal carinae tuberculated; dorsal external carinae formed by slightly spaced tubercles; external median carinae serrulated; ventral external carinae formed by spaced tubercles, well-formed only in the proximal one-third; anterior median formed by 13/12 spaced conical tubercles, varying in size; dorsal and ventral intercarinal spaces with granules of variable size. Patella: dorsal and ventral internal carinae tuberculated to granulated; dorsal external carinae rough; ventral external carinae from rough to granulated; dorsal intercarinal surface with a few scattered granules; ventral intercarinal surface almost smooth, only to few scattered minute granules near to ventral internal carinae is present. Dorsal patellar spur well developed. Chelal carina *D1* is distinct, strong, dark, smooth to rough; *D4* is rounded and rough; *V1* is distinct, strong, dark and rough with a few serrulated tubercles proximally; *V3* rounded, dark, smooth to rough; external carina granulated; intercarinal tegument from smooth to rough with granules of variable size. Typical *Euscorpius* chela finger dentition.

***Trichobothria*:** Chela: trichobothria on the pedipalp manus ventral surface 4/4 ($V_{1\text{-}3}$ + Et_1). Patella ventral (*Pv*): 6/6. Patella external (*Pe*): *et* = 5/5, *est* = 4/4, *em* = 3/3, *esb* = 2/2, eb_a = 4/4, *eb* = 4/4. Femur: trichobothrium *d* is slightly proximal to *i*, while trichobothrium *e* is distal to both *d* and *i*, and situated on dorsal external carina.

***Legs*:** With two pedal spurs; no tarsal spur; ventral row of tarsus III with a total of 8/6 worn-out spinules, of increasing size from proximal to distal, ending with a decentralized spinule. Granulation well present on dorsal and ventral surface of leg femora, it is mostly marked and dark ventrally.

***Chelicerae*:** Movable finger: the dorsal distal denticle is much smaller than the ventral distal denticle; ventral edge is smooth with brush-like setae on the inner part; dorsal edge has five denticles: one large distal, two small subdistal, one large median, and a small basal. Fixed finger has four denticles: one distal, one subdistal, one median, and one basal, the last two in a fork arrangement; the internal surface has brush-like setae.

Discussion

The species of the genus *Euscorpius* in Bulgaria have been insufficiently studied. Limited information was given mostly in relatively recent papers (Valle 1975, Fet 2000, Teruel et al. 2004, Fet & Soleglad 2007). Some authors assumed the possibility of new species present in Bulgaria (Teruel et al. 2004, Fet & Soleglad 2007); however, they did not focus on resolving the systematic position of these forms, but rather grouped several populations based on their morphology, and addressed them as belonging to species groups or complexes: "*E. carpathicus* complex", "*E. hadzii* complex" and "*E. mingrelicus* complex".

Recently, two new Bulgarian species were described: a widespread *Euscorpius deltshevi* Fet, Graham, Webber & Blagoev, 2014 (a form of "*E. carpathicus* complex"), from the Stara Planina (= Balkan) Mts. in central Bulgaria; and a more localized *E. solegladi* Fet, Graham, Webber & Blagoev, 2014 (a form of "*E. hadzii* complex"), from south-western Bulgaria. Both of these species belong to the subgenus *Euscorpius* s.str.

In addition, Parmakelis et al. (2013), in a large phylogenetic study of *Euscorpius* from Greece and adjacent countries, included two other populations from the south-western Bulgaria, which are not closely related to two species described by Fet et al. (2014), but instead group with several populations from northeastern Greece (clade E4 in Parmakelis et al. 2013). In our current opinion, these closely related populations belong to several good species which our team is currently describing (Tropea et al. in prep.).

The new species described in this paper, *E. drenskii*, has not been included in the study of Parmakelis et al. (2013). However, we used *16S rDNA* to construct a phylogenetic tree, which places this species in a clade outside of the subgenus *Euscorpius* s.str., together with the neighbouring populations from southwestern Bulgaria and northeastern Greece (clade E4 in Parmakelis et al. 2013). This confirms that *E. drenskii*, *E. carpathicus* (type species of the subgenus *Euscorpius* s.str.) and the subgenus *Alpiscorpius* are three distinct and strongly supported clades with a long history of independent evolution, despite of the peculiar reduced trichobothrial series *em* = 3.

According to our preliminary phylogeny constructed based on *16S* rDNA data, *E. drenskii*, together with other populations from southwestern Bulgaria and northeastern Greece form a larger clade, with *Euscorpius avcii* as its closest clade. This clade is well-separated from the subgenus *Polytrichobotrhius* Birula, 1917 (type species *E. italicus*) as well as from the subgenus *Euscorpius* Thorell, 1876 s.str. (here

represented by *E. carpathicus*, *E. tergestinus*, and *E. concinnus*).

E. drenskii exhibits genetic distance of 3.4 % to 5.5 % from other populations of its clade (clade E4 in Parmakelis et al. 2013), which is equal or higher than among other closely related species (e.g., *E. carpathicus* has a genetic distance of 3.4 % and 3.1 % from *E. tergestinus* and *E. concinnus*, respectively), and 7.8 % to 14.2 % from the remaining species of our phylogenetic tree. Note the large genetic divergence shown between *E. drenskii* and *E. carpathicus* (type species of the subgenus *Euscorpius*), which is 7.8 %, and with *E. germanus* (type species of the subgenus *Alpiscorpius*), which is as high as 11.9 %. It is clear that the new species does *not* belong to the subgenus *Euscorpius* s.str., and that the shared condition of *em* = 3 between these three groups is homoplasious.

Regarding its trichobothrial pattern, *E. drenskii* is one of the most oligotrichous species in the entire genus *Euscorpius*; in fact, only a few species of the subgenus *Alpiscorpius* have a lower summary number of patellar trichobothria (*Pv* + *Pe*) (e.g. *E. germanus*, *E. alpha* and *E. gamma*). So far, no species has been described with such low values outside of the subgenus *Alpiscorpius* (or related to it). With *Pv* = 6 and *Pe* = 22 (*et* = 5 and *em* = 3), *E. drenskii*. has the same trichobothrial values as *E. mingrelicus* s.str. and *E. croaticus* Di Caporiacco 1950, and an even lower value than *E. mingrelicus ciliciensis* Birula 1898 (*Pv* = 7 and *Pe* = 22). It should be also be noted that, among the populations phylogenetically close to *E. drenskii*, none have *em* = 3, and most have *Pv* = 6–9 and *Pe* = 23–25 (*et* = 5–7 and *em* = 4) (Tropea et al. in prep.). Thus this character state is probably independently derived (autapomorphic). A very similar situation is presented by *E. carpathicus* in south-western Romania, which has *em* = 3, while phylogenetically close *E. deltshevi* from Serbia and northern Bulgaria has *em* = 4 (Fet et al. 2014, unpublished data of Tropea).

With its trichobothrial pattern, which should be considered the most clear diagnostic character set for *E. drenskii*, it can be easily distinguished from most of the other *Euscorpius* species. In fact, as explained above, only *E. carpathicus*, *E. mingrelicus*, and *E. croaticus* have exactly the same trichobothrial pattern as *E. drenskii*. However, *E. drenskii* can be quite readily differentiated from these forms as follows:

From *E. carpathicus*, *E. drenskii* is distinguished mainly by: (1) the number of *Pv* = 6 in *E. drenskii* versus normally 8 in *E. carpathicus*; (2) *E. drenskii* has *Pe-et* = 5 versus usually 6 and 7 in *E. carpathicus*. In addition, *E. carpathicus* has a dark brown colour, and inhabits south-western Romania.

From *E. mingrelicus*, *E. drenskii* can be easily distinguished by the ratio of distances between trichobothria on fixed finger, *et-est / est-dsb*, which is > 1.5 in *E. mingrelicus* complex (Bonacina 1980), while it is just over 1 in *E. drenskii*. In addition, *E. mingrelicus* has a dark brown colour.

The last species, which has the same number of trichobothria as *E. drenskii*, is *E. croaticus*. This form has recently been elevated to the status of species by Graham et al. (2012), and, according to their phylogenetic tree based on COI data, it clustered with the subgenus *Alpiscorpius*. However, due to its ambiguous morphological features, *E. croaticus* has not been assigned to any subgenus (for more information see Graham et al. 2012). Fet (1993) identified specimens of *E. drenskii* from Trigrad, Bulgaria, as *E. croaticus*. However, while the latter groups with the subgenus *Alpiscorpius*, in our phylogeny *E. drenskii* forms a clade strongly separated from *Alpiscorpius*. Morphologically, these two species can be distinguished by (1) a different number of pectinal teeth, 8–9 in males and 7 in females of *E. drenskii*, versus 6–7 (usually 7) in males and 5–6 (usually 6) in females of *E. croaticus* (Tropea, unpublished data); (2) a slightly shorter metasoma in proportion to the carapace in *E. drenskii*; on average 2.81 (maximum ratio 2.89) in *E. drenskii* versus 3.01 in the lectotype of *E. croaticus*; (3) a more slender metasoma in *E. drenskii*; *Lmet/Wmet* on average 1.75 (lowest value 1.74) in *E. drenskii*, compared to 1.66 in the lectotype of *E. croaticus*. In addition, *E. croaticus* is found only in northwestern Croatia (Di Caporiacco 1950, Bonacina 1980, Graham et al. 2012).

Conclusions

In the past, the genus *Euscorpius* has been intensively studied; over 40 species and subspecies were described. Most of these taxa were later downgraded to subspecies status or moved to synonymy. However, since 1999, when this genus had only 4 recognized species, the number steadily increased and has gradually reached 17 in 2007. Thanks to further detailed studies, based both on morphological and molecular data, from 2012 to the present, the species number now increased to 43 (including *E. drenskii*), and several other species are in press or in description. This large increase in species diversity, and in the studies

that led to establishing these taxa, reflect a great degree of speciation and endemism in *Euscorpius*, which are often restricted to very limited areas such as a mountain range or an island, or a small group of mountains or islands.

Another interesting point that was understood during these studies, and noted for the first time by Tropea (2013), is that the existing subgeneric division of the genus *Euscorpius* was not consistent with the taxonomic situation. Parmakelis et al. (2013), in a much larger and detailed molecular phylogenetic study, arrived at the same result. Currently, there are a number of forms without a clear subgeneric placement. These include the new species described herein, *E. drenskii*. According to a traditional identification key, it is a part of the subgenus *Euscorpius*, but genetically it is completely separate, and could belong to a separate subgenus (or even genus); therefore we addressed it here as a "subgenus incertus".

Further studies, resulting in improved identification keys, are needed to bring order in this growing and complicated scorpion group. This goal could be supported by a study of hemispermatophores, which was quite decisive, e.g., in the recent revisions of scorpion genera *Iurus* Thorell, 1876 and *Protoiurus* Soleglad, Fet, Kovařík & Yağmur, 2012 (Iuridae) (Kovařík et al. 2010, Soleglad et al. 2012). Using hemispermatophores is not an easy or universal criterion, as they are only present in males, which are usually represented in collections by fewer number than the females. In addition, to analyse these organs, the specimens must be dissected, and a high variability between specimens and even between the left and right hemispermatophore is present in *Euscorpius* (Tropea pers. obs.). Thus, to obtain a reliable result, a large number of adult males should be dissected. It must be pointed out, however, that in *E. drenskii* these organs, although variable, show a more complex secondary acuminate process than in many other *Euscorpius*, but are nevertheless similar to other Balkan populations related to *E. drenskii* (Tropea in prep.).

Acknowledgements

We are grateful to all colleagues who kindly loaned and shared types and comparative material with us, and helped in field collection and laboratory procedures, including (but not limited to) Petar Beron, Vladimir Beshkov, Gergin Blagoev, Alberto Bonacina, Matt Braunwalder, Michael Brewer, Christo Deltshev, Dobrin Dobrev, Elizabeth Fet, Galina Fet, Simon Fet, Benjamin Gantenbein, Matthew Graham, Kirill Mikhailov, Plamen Mitov, Ivan Pandourski, Paolo Pantini, Boyan Petrov, Valentin Popa, Alexi Popov, Dimitar Raichev, Vladimir Sakalian, Michael Soleglad, Pavel Stoev, and Milen Vassilev. Special thanks are to Petar Beron, who loaned the entire NMNHS collection of *Euscorpius* to V.F., to Alexi Popov who meticulously checked and corrected all Bulgarian toponyms, and to Michael Soleglad who kindly provided a map (Fig. 20). V.F.'s initial travel to Bulgaria in 1999 was supported by a COBASE (Cooperation in Basic Science and Engineering) grant from the National Research Council, Washington, DC, USA. More extended V.F.'s travel to Bulgaria in 2005 was supported by the Fulbright Scholar Award 04-11-08 from CIES (Council of International Exchange of Scholars), Washington, DC, USA, which allowed Victor and Galina Fet to travel and live in Bulgaria in January–May 2005. Help, hospitality, and friendship of numerous Bulgarian colleagues made the 1999 and 2005 visits productive and enjoyable. Especially notable was a wonderful journey of V.F. across the West Rhodopes with Vlado Sakalian and Milen Vassilev in May–June 1999.

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The species of the pseudoscorpion genus *Pseudoblothrus* (Pseudoscorpiones: Syarinidae) in Italy (on Italian pseudoscorpions XLVIII)

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doi: 10.5431/aramit4903

Abstract. The species of the genus *Pseudoblothrus* Beier, 1931 from Italy are revised. Two species are present in this area: *P. peyerimhoffi* (Simon, 1905) (Piedmont) and *P. regalini* Inzaghi, 1983 (Lombardy). The following synonymy is proposed: *Pseudoblothrus ellingseni* (Beier, 1929) is a junior subjective synonym of *P. peyerimhoffi* (Simon, 1905) (**syn. nov.**). A key to all species of the genus *Pseudoblothrus* is provided.

Keywords: Alps, biospeleology, new synonymy, taxonomy

Three genera of the family Syarinidae are known from Italy: *Microcreagrina* Beier, 1961 with the epigean *M. hispanica* (Ellingsen, 1910) from Sicily and Sardinia, *Hadoblothrus* Beier, 1952 with the subterranean *H. gigas* (di Caporiacco, 1951) from Apulia and *Pseudoblothrus* Beier, 1931 with three subterranean species from northern Italy (Gardini 2000).

The genus *Pseudoblothrus*, established for *Ideoblothrus roszkovskii* Redikorzev, 1918 from Crimea, is represented in Europe by ten subterranean species (Harvey 2013), described from the Azores Archipelago (*P. oromii* Mahnert, 1990 and *P. vulcanus* Mahnert, 1990), the French and Italian western Alps [*P. peyerimhoffi* (Simon, 1905) and *P. ellingseni* (Beier, 1929)], the Italian central Alps (*P. regalini* Inzaghi, 1983), Swiss and French Jura Mountains (*P. strinatii* Vachon, 1954), Switzerland (*P. thiebaudi* Vachon, 1969 and *P. infernus* Mahnert, 2011) and Crimea [*P. roszkovskii* (Redikorzev, 1918) and *P. ljovuschkini* Krumpál, 1984]. Relationships between the species listed above and between *Pseudoblothrus* and related genera of Syarinidae, chiefly *Chitrella* Beier, 1932 from North America, are still uncertain, as discussed in detail by Zaragoza (2010).

The necessity of reviewing the *P. peyerimhoffi* – *P. ellingseni* complex has been pointed out by Mahnert (1980), Inzaghi (1983) and Gardini (2000). The results obtained during intensive speleological investigations in the western Alps, chiefly carried out during the last ten years by Enrico Lana (Chivasso, Torino), have made available a sufficient number of these rare pseudoscorpions for this purpose. Moreover, examination of further specimens of *P. regalini* from Lombardy allows a supplementary description of this species.

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Submitted 25.2.2015, accepted 15.5.2015, online: 29.5.2015

Material and methods

This study is based on the examination of 38 adult specimens and 1 tritonymph of *Pseudoblothrus*, all lodged in the collection of the author. Specimens were cleared in 60% lactic acid and temporarily mounted – after dissection of right palp, chelicera, legs I and IV – in cavity slides with the same medium. Each specimen was returned, after study, to a vial of 70% ethanol together with the dissected portions placed in glass capillary tubes. All specimens were studied using an Olympus BHB compound microscope and illustrated with the aid of a Nachet drawing tube. Measurements and proportions are given as length/breadth for carapace, chelicerae and pedipalps and as length/depth for legs; measurements are expressed in mm. For reference points, used to take measurements, see Chamberlin (1931).

Only references to publications useful for a correct understanding of the taxon are cited. Synonymies are supplied in the case of changes relative to the catalogue of Harvey (2013), as a consequence of revised identifications. The localities of examined specimens are listed in the order of SW to NE. Names of caves are followed by their current cadrastal number.

Taxonomy

Pseudoblothrus peyerimhoffi (Simon, 1905)

(Figs 1-27, 50)

Obisium torrei (not Simon, 1881): Ellingsen 1905: 9 (misidentification).

Blothrus peyerimhoffi Simon, 1905: 282; Vachon 1938: 66, 67, figs 37i, 38a.
Obisium (Blothrus) ellingseni Beier, 1929: 363 (**syn. nov.**).
Neobisium (Blothrus) peyerimhoffi: Beier 1932: 83, 113.
Neobisium (Blothrus) ellingseni: Beier 1932: 83, 113.
Pseudoblothrus peyerimhoffi: Vachon 1945: 230, figs 1-7; Vachon 1947: 318; Vachon 1952: 536; Vachon 1954: 217; Beier 1963: 229; Vachon 1969: 392; Mahnert 1980: 33, figs 15-16; Inzaghi 1983: 46; Isaia *et al.* 2011: 210, figs 5.22-5.24.
Pseudoblothrus ellingseni: Beier 1963: 228; Vachon 1969: 392; Mahnert 1980: 30, figs 13-14; Muchmore 1982: 218; Inzaghi 1983: 46; Bologna & Vigna Taglianti 1985: 65, 228; Isaia *et al.* 2011: 203, 209, figs 5.19-5.21.
Pseudoblothrus sp. prope *peyerimhoffi*: Vigna Taglianti 1969: 267.
Pseudoblothrus ellingseni (ssp.?): Mahnert 1980: 32.

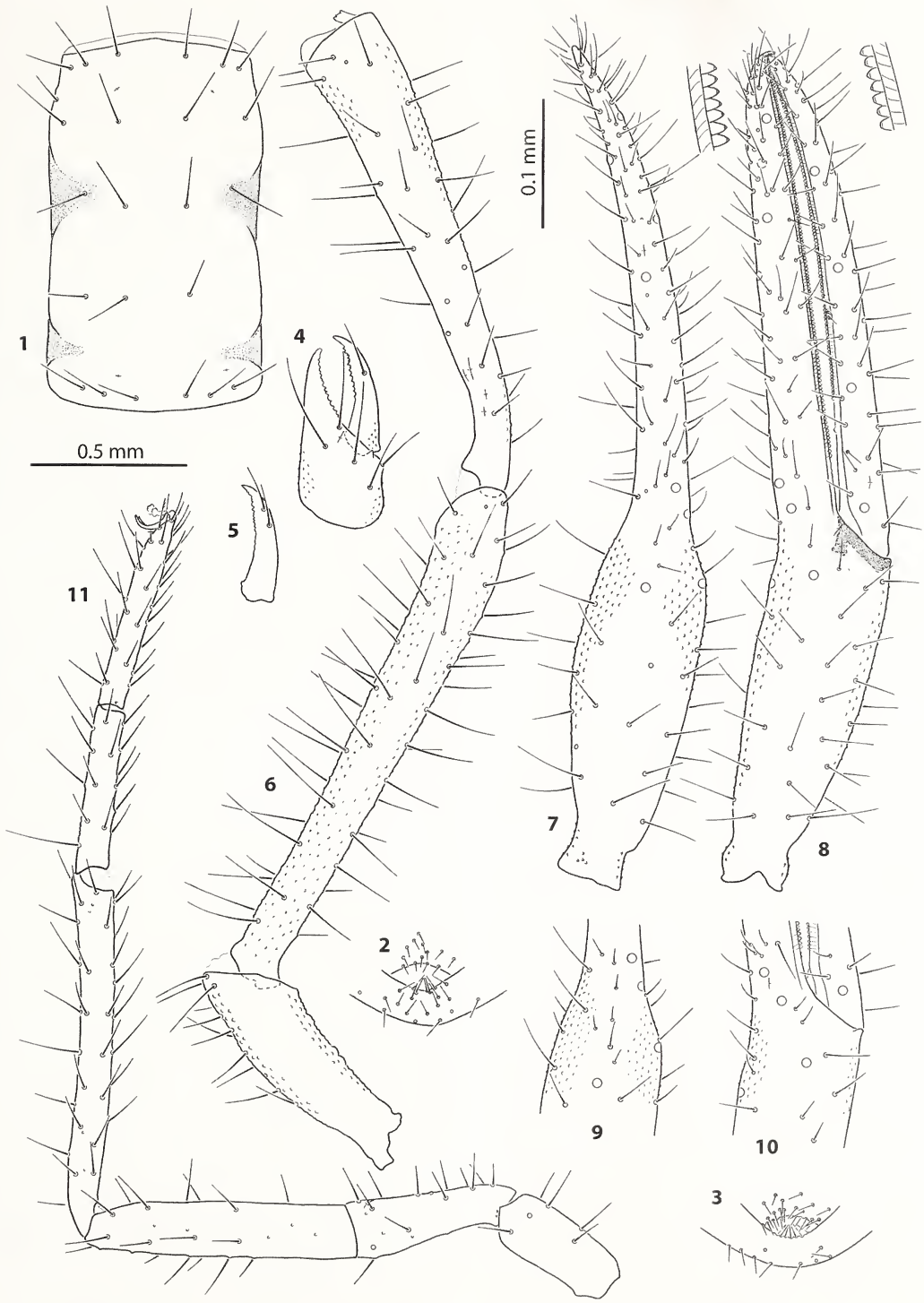
Type localities. FRANCE, Alpes-de-Haute-Provence, Méailles, Grotte de Mélan (44°03'18"N 6°37'33"E) and Trou du Perthus (= Pertuis) (44°02'02"N 6°37'33"E). ITALY, Piedmont, Frabosa Soprana, Grotta di Bossea n. 108 Pi/CN (44°14'31"N 7°50'27"E).

Distribution. SE France (departments of Alpes-Maritimes, Alpes-de-Haute-Provence, Drôme and Isère), NW Italy (Piedmont) (Fig. 50).

Diagnosis (♂♀). A subterranean *Pseudoblothrus* from the western Alps of France and Italy that differs from other species of the genus in the following combination of characters: no eyes or eye-spots; anterior and posterior rows of carapace with 6 setae each; male without ventral glands on sternite VI, sternites without fields of glandular pores; sternites III and IV respectively with 4 and 3 suprastigmal setae; pedipalp granulate; pedipalpal femur length 1.34–2.24 mm (6.9–8.9 times as long as broad), patella 1.20–2.12 mm (5.0–6.8×), chela with pedicel 2.13–3.18 mm (6.0–7.5×); fixed and movable chelal fingers with 100–150 and 91–153 teeth respectively.

Material examined. FRANCE – *Alpes-Maritimes*: 1 ♂, Séranon, Embut de Rouaine 134-A, 1164 m a.s.l., 11.VIII.1991, E. Piva leg. ITALY – *Piedmont, Cuneo Prov.*: 1 ♂, Valdieri, Valle Infernotto, Sweet Inny or Maissa 10 n. 1218 Pi/CN (U.T.M. coordinates: 32T 373153 4902351), 1047 m a.s.l., 8.VIII.1912, E. Lana leg.; 1 tritonymph, Vernante, Vallone di Palanfrè: Grotta G-4 della Lausea n. 1130 Pi/CN (U.T.M. coordinates: 32T 379920 4893530), 1530 m a.s.l., 28.VII.2012, E. Lana leg.; 1 ♂ 1 ♀, Limone Piemonte, Colle di Tenda, Buco di Napoleone art. Pi/CN (U.T.M. coordinates: 32T 386064 4890982), 1475 m a.s.l., 23.VII.1988, R. Sciaky leg.; 1 ♂ 1 ♀, id., 30.IX.2001, E. Lana leg.; 4 ♂ 6 ♀, id., 4.VII.2014, M. Chesta & E. Lana leg.; 1 ♂, Briga Alta, Massiccio del Marguareis, Abisso F33, 14.VIII.1985, E. Piva leg.; 1 ♀, Frabosa Soprana, Grotta di Bossea n. 108 Pi/CN, 836 m a.s.l., 16.III.2003, E. Lana leg.; 3 ♂, Frabosa Soprana, Grotte della Mottera n. 242-675 Pi/CN, 27.VII.1986, S. Zoia leg.; 1 ♀, Garessio, Pozzo del Villaretto n. 273 Pi/CN (U.T.M. coordinates: 32T 417950 4889397), 1100 m a.s.l., 22.XI.2009, E. Lana leg.; 1 ♂, Lisio, Grotta di Rio dei Corvi n. 884 Pi/CN, 800 m a.s.l., 29.X.2006, E. Lana leg.; 1 ♂, Roccaforte Mondovì, Grotta dell'Argilla o D-1 del Mongioie n. 168 Pi/CN (U.T.M. coordinates: 32T 401424 4892621), 1995 m a.s.l., 10.VII.2011, E. Lana & A. Pastorelli leg.; 1 ♀, Villanova Mondovì, Grotta Superiore dei Dossi n. 106 Pi/CN, 626 m a.s.l., 23.II.2002, C. Arnò & E. Lana leg. *Piedmont, Torino Prov.*: 1 ♀, Ala di Stura, Borna o Cava del Servais C art. Pi/TO (U.T.M. coordinates: 32T 369010 5020260), 1405 m a.s.l., 13.VI.2012, E. Lana leg. *Piedmont, Biella Prov.*: 1 ♂, Quittengo, Alpe Machetto, artificial gallery, 1250 m a.s.l., 20.IV.1996, T. Pascutto leg. *Piedmont, Vercelli Prov.*: 2 ♂, Varallo, Monte Camossaro, Grotta Ovaighe n. 2516 Pi/VC, 980 m a.s.l., 24.III.2002, T. Pascutto & L. Collivassone leg. *Piedmont, Verbania Prov.*: 1 ♀, Verbania, Monte Spalavera, Prospetto di Miniera art. Pi/VB, 1150 m a.s.l., 1.XI.1994, E. Lana leg.

Description of adults (♂♀). Carapace, pedipalps and first tergite reddish brown, tergites II–XI yellowish brown; hispid granulation on cheliceral palm, on base of movable cheliceral finger and on pedicel of pedipalpal chela; rounded granulation on trochanter, femur, patella and hand of pedipalp; pleural membrane striate. Carapace (Figs 1, 12) 1.65–1.8 times as long as broad, without eyes or eye-spots, with two transverse furrows, the subbasal one narrower; anterior margin without epistome, rarely weakly prominent medially; 24–32 fine macrosetae, 6 (rarely 5 or 7) in anterior, 6 (rarely 7) in posterior row, standard chaetotaxy 6:6:4:6:6(28). Chaetotaxy of tergites I–XI 6:8–10:9–11:10–14:12–14:12–14:12–14:12–14:12–14:8–12(4 tactile setae):7–8(4 tactile setae); tergite I rarely with 5 or 7 setae, II 7 or 11, III 12 or 13, VI 11 or 15, IX 11, X 7, XI 6 or 9 setae. Chaetotaxy of

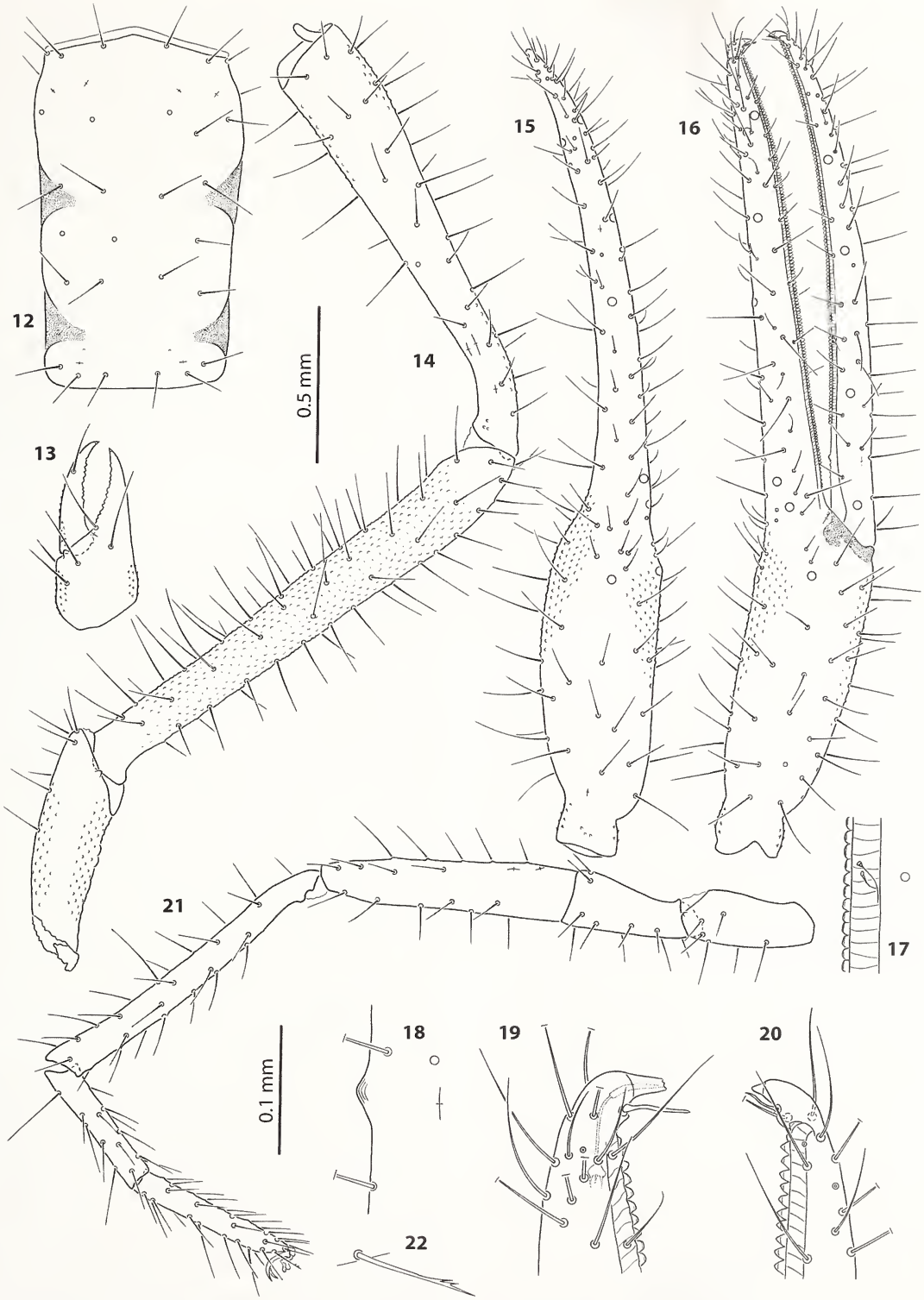


Figs 1-11: *Pseudoblothrus peyerimhoffi* (Simon, 1905), male. **1:** carapace (France: Séranon); **2:** genital opening (France: Séranon); **3:** id. (Italy: Quittengo); **4:** right chelicera (France: Séranon); **5:** movable finger of right chelicera with abnormal presence of two setae (Italy: Quittengo); **6:** trochanter, femur and patella, right pedipalp (France: Séranon); **7:** right chela, dorsal view (France: Séranon); **8:** id., lateral view with details of subapical teeth (France: Séranon); **9:** detail of right chela with trichobothria *ib-eb-esb-isb*, dorsal view (Italy: Quittengo); **10:** id., lateral view (Italy: Quittengo); **11:** left leg IV (France: Séranon). (Scale bar 0.5 mm; 0.1 mm: details of fig. 8)

sternites (♂) II: 13–24 (4–10 of which along anterior margin of genital opening: Figs 2–3), III: 12–28 (4–14 of which discal or along posterior margin of genital opening: Figs 2–3), IV: 12–14 + 3–7 discal setae, V: 11–14 + 5–8 discal setae, VI: 12–16 + 4–10 discal setae, VII–XI: 12–17:12–16:12–16:12–16:7–9; genital chamber with 2 unmodified setae; sternite VI without glandular area; chaetotaxy of sternites II–XI (♀): 8–16:12–18:8–12:12–15:12–17:13–17:13–15:13–15:11–13:7–9; sternites IV–VI of ♀ without discal setae; sternites III and IV (♂♀) respectively with 4 (rarely 3) and 3 (rarely 2 or 4) microsetae in front on each stigma; anal cone with 2+2 setae. Chelicera (Figs 4, 12) 2.1–2.35 (♂) or 2.0–2.3 (♀) times as long as broad, palm with 5 setae, fixed and movable fingers respectively with 13–20 and 8-16 subequal teeth, *gl* ratio 0.64-0.78 (additional teratological seta in right movable finger of the male from Quittengo: Fig. 5), spinneret absent (silk ducts not seen), rallum with 6–7 finely dentate blades, the median ones side-by-side; serrulae interior and exterior respectively with 16–21 and 22–27 blades. Manducatory process triangular and acuminate, with 2 setae. Coxal setae: pedipalp 9-12 (mostly 10, rarely 8 or 13), I 6–8 (rarely 5), II 6–8 (rarely 5 or 9), III 3–4 (rarely 5), IV 7–10 (rarely 6); anterolateral process of coxa I prominent, apically acuminate or truncate. Pedipalp (Figs 6–10, 14–16): trochanter 3.3–3.9 (♂) 3.1–4.2 (♀) times as long as broad, granulate, with one or two button-like tubercles on antiaxial face; femur 6.9–8.9 (♂) or 7.15–8.15 (♀) times as long as broad, granulate, weakly and gradually enlarged distally; patella 5.0–6.8 (♂) or 5.0–5.9 (♀) times as long as broad, club-shaped, weakly granulate on antiaxial face of pedicel and on both lateral faces of club; chela with pedicel 6.25–7.5 (♂) or 6.0–7.1 (♀) times as long as broad; hand of chela with pedicel 2.4–3.3 (♂) or 2.4–3.1 (♀) times as long as broad, cylindrical, finely granulate from *esb* to the base (♂) or to the proximal third (♀), pedicel with hispid granulation; fixed chelal finger with 100–150 (♂♀) small, pointed contiguous teeth with dental canals (Figs 8, 16); base of fixed finger with 5–8 microtubercles; tip of fixed finger as in Fig. 19, venom duct short; movable chelal finger with 91–153 (♂♀) small contiguous teeth with dental canals reaching back beyond *sb* (Figs 8, 16–17), only the 15–30 distal teeth pointed (Fig. 20); coupled sensilla *pc* in variable position between *sb* and *st* and a large tubercle (sensillum?) between *b* and *sb* (Fig. 18); trichobothria as in Figs 7–10 and 15–16, *ib* mostly slightly proximad *eb*, both on distal third of the hand; trichobothrium *t* simple, slightly shorter than *st* and weakly bent backward; ratio of movable finger/hand of chela with pedicel 1.35–1.7 (♂) or 1.4–1.7 (♀); ratio of pedipalpal femur/movable finger 0.95–1.15 (♂♀); ratio of pedipalpal femur/carapace 1.3–1.65 (♂) or 1.25–1.45 (♀). Leg I (♂♀): femur 5.5–7.6 times as long as deep and 1.6–1.8 times longer than patella, the latter 3.3–4.7 times as long as deep, tibia 6.5-8.6 times, basitarsus 4.1–4.9, telotarsus 5.7-7.2 times as long as deep and 1.2-1.4 times longer than basitarsus, subterminal seta dentate, arolium shorter than claws, these ones smooth; leg IV (♂♀) (Figs 11, 21): femur+patella 6.1–7.6 times as long as deep, ratio of femur/patella 0.53–0.63; tibia 8.8-10.7 times, basitarsus 4.3–5.35 times, telotarsus cylindrical, not expanded, 6.0-8.5 as long as deep and 1.15–1.2 longer than basitarsus; junction between femur and patella perpendicular, subterminal seta dentate (Fig. 22), arolium shorter than claws, latter smooth.

Measurements (in mm). Body length 3.1–4.5 (♂♀). Carapace 1.0–1.36 × 0.57–0.75 (♂) or 1.0–1.32 × 0.60–0.72 (♀). Chelicera 0.52–0.64 × 0.22–0.30 (♂) or 0.49–0.63 × 0.23–0.31 (♀); movable finger length 0.33–0.41 (♂) or 0.32–0.41 (♀). Pedipalp: trochanter 0.68–1.05 × 0.20–0.28 (♂) or 0.65–0.94 × 0.20–0.22 (♀); femur 1.34–2.24 × 0.19–0.25 (♂) or 1.36–1.90 × 0.19–0.27 (♀); patella 1.22–2.12 × 0.235–0.32 (♂) or 1.22–1.80 × 0.24–0.32 (♀); chela with pedicel 2.19–3.18 × 0.31–0.44 (♂) or 2.13–2.85 × 0.35–0.44 (♀); hand with pedicel length 0.86–1.28 (♂) or 0.86–1.20 (♀); movable finger length 1.36–2.05 (♂) or 1.35–1.68 (♀). Leg I: femur 0.68–1.12 × 0.12–0.165 (♂) or 0.665–0.92 × 0.12–0.15 (♀), patella 0.40–0.62 × 0.115–0.13 (♂) or 0.38–0.55 × 0.115–0.14 (♀), tibia 0.56–0.91 × 0.085–0.105 (♂) or 0.55–0.86 × 0.085–0.10 (♀), basitarsus 0.285–0.44 × 0.07–0.09 (♂) or 0.29–0.44 × 0.07–0.09 (♀), telotarsus 0.40–0.55 × 0.065–0.08 (♂) or 0.40–0.52 × 0.07–0.08 (♀); leg IV: femur+patella 1.10–1.68 × 0.15-0.22 (♂) or 1.10–1.43 × 0.17–0.20 (♀), tibia 0.89–1.40 × 0.10–0.135 (♂) or 0.88–1.27 × 0.10–0.14 (♀), basitarsus 0.40–0.59 × 0.085–0.11 (♂) or 0.41–0.54 × 0.085–0.11 (♀), telotarsus 0.46–0.68 × 0.075–0.085 (♂) or 0.47–0.63 × 0.075–0.09 (♀).

Description of tritonymph. Carapace, tergites and pedipalps pale reddish brown, granulation on pedipalps weak. Carapace 1.8 times longer than broad, without epistome, no eyes or eye-spots, with two transverse furrows, chaetotaxy 6:6:4:6:6(28).



Figs 12-22: *Pseudoblothrus peyerimhoffi* (Simon, 1905), female from Italy: Bossea. **12:** carapace; **13:** left chelicera; **14:** trochanter, femur and patella, right pedipalp; **15:** right chela, dorsal view; **16:** id., lateral view; **17:** movable chelal finger, detail of teeth and coupled sensilla; **18:** id., detail of tubercle between *b* and *sb*; **19:** apex of fixed chelal finger, lateral view; **20:** apex of movable chelal finger, lateral view; **21:** right leg IV; **22:** subdistal seta of leg IV. (Scale bar 0.5 mm: figs 12-16, 21; 0.1 mm: figs 17-20, 22)

Chaetotaxy of tergites I–V: 6:8:11:12:13. Chaetotaxy of sternites not determined (opisthosoma crumpled). Chelicera 2.0 times as long as broad, palm with 5 setae, fixed and movable fingers respectively with 12 and 10 subequal teeth, *gl* ratio 0.68, spinneret absent, rallum with 5 blades; serrulae interior and exterior respectively with 15(?) and 17 blades. Manducatory process triangular, with 2 setae. Coxal setae: pedipalp 6–7, I 4–5, II 5, III 3, IV 5–6. Pedipalp (Figs 23–27): trochanter 2.7 times as long as broad, with one button-like tubercle on antiaxial face, femur 5.1 times, patella 3.75 times, chela with pedicel 5.2 times, hand of chela with pedicel 2.15 times as long as broad; fixed chelal finger with 62 contiguous teeth with dental canals and 8 basal microtubercles, venom duct short; movable chelal finger with 66 contiguous teeth with dental canals reaching back halfway between *b* and *sb*; coupled sensilla *pc* at level of *st* and large tubercle (sensillum?) between *b* and *st* (Fig. 27); tip of chelal fingers as in Fig. 26; trichobothria as in Figs 24–25; ratio of movable finger/hand of chela with pedicel 1.5; ratio of pedipalpal femur/movable finger 1.0; ratio of pedipalpal femur/carapace 1.05. Leg I: femur 4.0 times as long as deep and 1.7 times longer than patella, the latter 2.6 times as long as deep, tibia 4.45 times, basitarsus 2.8, telotarsus 3.9 times as long as deep and 1.4 times longer than basitarsus, subterminal seta, arolium and claws as in adults; leg IV: femur+patella 5.0 times as long as deep, ratio of femur/patella 0.58; tibia 5.9 times, basitarsus 3.1 times, telotarsus not expanded, 3.85 as long as deep and 1.2 longer than basitarsus, junction between femur and patella, subterminal seta, arolium and claws as in adults.

Measurements (in mm). Body length 2.6 (?). Carapace 0.74 × 0.41. Chelicera 0.36 × 0.18; movable finger length 0.21. Pedipalp: trochanter 0.41 × 0.15; femur 0.77 × 0.15; patella 0.64 × 0.17; chela with pedicel 1.25 × 0.24; hand with pedicel length 0.52; movable finger length 0.79. Leg I: femur 0.38 × 0.095, patella 0.22 × 0.085, tibia 0.29 × 0.065, basitarsus 0.17 × 0.06, telotarsus 0.235 × 0.06; leg IV: femur+patella 0.60 × 012, tibia 0.475 × 0.08, basitarsus 0.22 × 0.07, telotarsus 0.27 × 0.07.

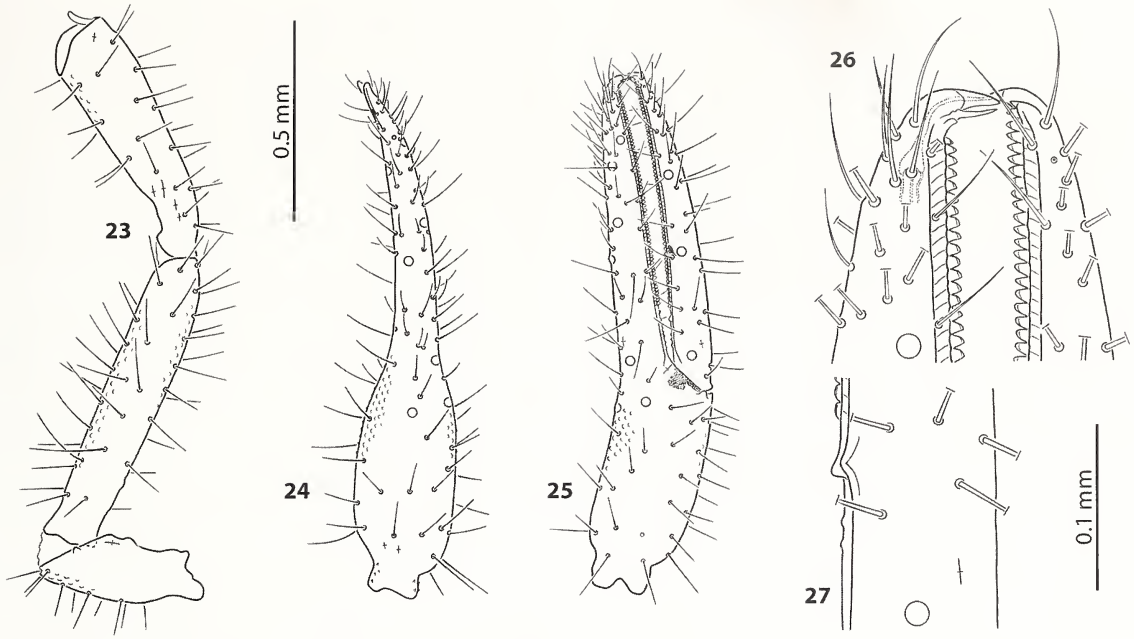
Remarks. A single specimen of a cavernicolous pseudoscorpion, collected by Alfredo Borelli in the cave of Bossea in Piedmont, was described by Ellingsen (1905) and misidentified as *Obisium (Blothrus) Torrei* Simon, 1881 (now *Neobisium (B.) torrei*), a species known at that time only from Oliero cave (= Covol dei Siori n. 600 V/VI near Valstagna, Veneto). Ellingsen's description is reasonably accurate, chiefly concerning details of the carapace, highlighting the presence of two transverse furrows, the shape of the pedipalps and of the movable cheliceral finger; the following measurements (in mm) were also given: carapace 1.31 × 0.72, pedipalpal trochanter 0.80 × 0.24, femur 1.76 × 0.24, patella 1.60 × 0.32, hand 1.07 × 0.40, fingers 1.92.

Probably unaware of Ellingsen's paper, Simon (1905) described *Blothrus peyerimhoffi* a few months later from specimens of both sexes collected by Paul de Peyerimhoff in the caves of Mélan and Pertuis (Alpes-de-Haute-Provence) and by Agostino Dodero in the cave of Bossea. Simon's description is vague, apart from a few details on the shape of the carapace and the pedipalp.

Beier (1929) proposed the name *Obisium (Blothrus) Ellingseni* Beier, 1929 for the material from Bossea cave described by Ellingsen (1905), without examining any material. In so doing, he overlooked the paper of Simon (1905) and consequently did not notice that Bossea cave was also one of the localities of *Blothrus peyerimhoffi*. Beier (1932) included both species in the genus *Neobisium* (= *Obisium* Leach, 1815), subgenus *Blothrus* Schiödte, 1847, using the original data of Ellingsen (1905) and Simon (1905).

Vachon (1945) redescribed *N. peyerimhoffi* from syntypes from Mélan (or Pertuis), transferred the species from *Neobisium* (Neobisiidae) to *Pseudoblothrus* (Syarinidae), and gave a key to the species of the latter genus, including only *P. roszkovskii* and *P. peyerimhoffi*, making no mention of *O. ellingseni* (then still placed in *Neobisium*). Vachon (1945) was the first to revise *P. peyerimhoffi* and the species was subsequently cited (Vachon 1947, 1952) from the cave of Clue near Séranon (Alpes-Maritimes).

Beier (1963), without examining any material, proposed a key to European species of *Pseudoblothrus* using the data of Ellingsen (1905) and Vachon (1945) respectively for *P. ellingseni* and *P. peyerimhoffi*. The most important character used to separate the two species was the ratio of movable finger/hand of chela: 1.79 in *P. ellingseni*, 1.45 in *P. peyerimhoffi*. Later, Vachon (1969) included *P. peyerimhoffi*, together with *P. ellingseni*, in the key to species of *Pseudoblothrus* and Leclerc (1983, 1984) recorded *P. peyerimhoffi* from caves in the French departments of Isère and Drôme.



Figs 23-27: *Pseudoblothrus peyerimhoffi* (Simon, 1905), tritonymph from Italy: Vernante. **23:** trochanter, femur and patella, right pedipalp; **24:** right chela, dorsal view; **25:** id., lateral view; **26:** apex of chelal fingers, lateral view; **27:** movable chelal finger, detail of tubercle between *b* and *st*. (Scale bar 0.5 mm: figs 23-25; 0.1 mm: figs 26-27)

The contribution of Mahnert (1980) provided plenty of scope for a correct interpretation of relationships between *P. ellingseni* and *P. peyerimhoffi*. His redescription of *P. ellingseni* based on topotypes from Bossea, evaluation of morphological variability of neighbouring populations and redescription of *P. peyerimhoffi* from the cave of Clue allowed the presumption that differences between the species listed above were not substantial, as emphasized in his own (p. 35) conclusions. Differences in the form of the chelal palm and in granulation on the femur, as proposed by Mahnert (1980) in the key to species, cannot be considered sufficient to separate *P. ellingseni* and *P. peyerimhoffi* since they show high variability between sexes and among different populations.

The material examined here, together with those studied by Mahnert (1980), also reveals remarkable intrapopulational dimensional variability, as shown in ♂♀ from Bossea cave: pedipalpal femur 1.43–1.69 × 0.18–0.21 mm (7.6–8.3 times as long as broad), patella 1.24–1.52 × 0.22–0.265 mm (5.5–6.0 times as long as broad), chela with pedicel 2.27–2.58 × 0.32–0.37 mm (6.5–7.1 times as long as broad), movable finger length 1.46-1.70 mm, ratio of movable finger/hand of chela with pedicel 1.58–1.70. Interpopulational variability shows a much greater dimensional ranges. The higher dimensions were found in males from Ovaighe cave, Varallo: pedipalpal femur 2.22–2.24 × 0.25 mm (8.88–8.90 times as long as broad), patella 2.10–2.12 × 0.31–0.32 mm (6.56–6.80 times as long as broad), chela with pedicel 3.12–3.18 × 0.42–0.44 mm (7.2-7.4 times as long as broad), movable finger length 1.95–2.05 mm, ratio of movable finger/hand of chela with pedicel 1.54–1.60. The dimensions and proportions given by Vachon (1945) and Mahnert (1980) for both *P. peyerimhoffi* and *P. ellingseni* fall within the ranges presented here.

Furthermore, the improbable occurrence at the same locality (Bossea cave) of both *P. ellingseni* and *P. peyerimhoffi*, allows the following synonymy to be proposed: *Pseudoblothrus ellingseni* (Beier, 1929) is a junior subjective synonym of *P. peyerimhoffi* (Simon, 1905) (**n. syn**).

***Pseudoblothrus regalini* Inzaghi, 1983** (Figs 28-50)

Pseudoblothrus regalini Inzaghi, 1983: 38, figs 1–12.

Type locality. N ITALY, Lombardy, Bergamo Prov., Grone, Cave on NW slope of Grone Mt. (45°43'N 9°56'E).

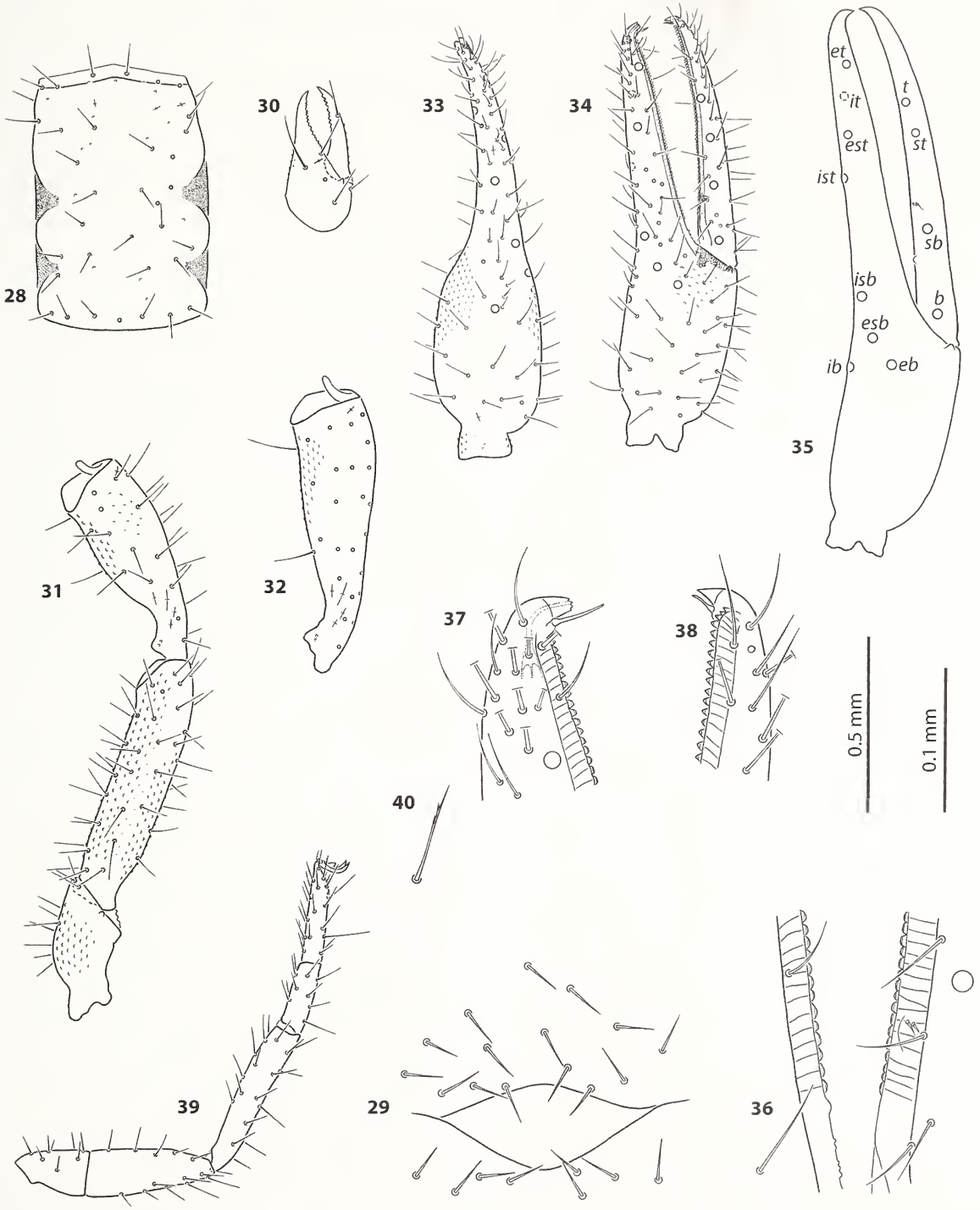
Distribution. Italy (Lombardy) (Fig. 50).

Diagnosis (♂♀). A subterranean *Pseudoblothrus* from northern Italy that differs from the other spe-

cies of the genus in the following combination of characters: no eyes or eye-spots; anterior and posterior rows of carapace with 6 setae each; male without ventral glands on sternite VI, sternites without fields of glandular pores; sternites III and IV each with 4 suprastigmal setae; pedipalp weakly granulate; pedipalpal femur length 0.73–1.05 mm (4.5–5.6 times as long as broad), patella 0.62–0.82 mm (2.8–3.6×), chela 1.22–1.60 mm (3.5–4.9×); fixed and movable chelal fingers respectively with 62–84 and 66–77 teeth.

Material examined. ITALY – *Lombardy, Lecco Prov.*: 1 ♀, Lecco, Piani Resinelli, disused lead mines, 1000 m a.s.l., 18.XI.1999, R. Monguzzi leg. *Lombardy, Brescia Prov.*: 1 ♂, Adro, Grotta Lachetto di Monte Alto n. 120 Lo/BS, 20.XI.1987, R. Monguzzi leg. *Lombardy, Bergamo Prov.*: 1 ♂ 1 ♀, Dossena, Mine on western slope of Vaccareggio Mt., 1250 m a.s.l., 17.VI.2014, M. Grottolo leg.; 1 ♂, id., 1.XI.2014; 2 ♀, Grone, Pozzo del Bosco Faét n. 1127 Lo/BG, 900 m a.s.l., 3.XI.1991, L. Latella & S. Zoia leg.; 1 ♂, Ardesio, Grotta della Poderizza n. 3505 Lo/BG, 845 m a.s.l., 19.XI.1992, R. Monguzzi leg.

Description of adults (♂♀). Carapace and pedipalps reddish brown, tergites yellowish brown; weak hispid granulation on cheliceral palm, on base of cheliceral movable finger and on pedicel of pedipalpal hand; rounded granulation on trochanter, femur, patella and hand of pedipalps; pleural membrane striate. Carapace (Figs 28, 41) 1.2–1.55 times as long as broad, without eyes or eye-spots, with two weak transverse furrows, the subbasal one narrower; anterior margin without epistome, rarely with a weak prominence; 32–36 fine macrosetae, 6 in anterior, 6 (rarely 7 or 8) in posterior row, standard chaetotaxy presumably 6:8:6:8:6(34). Chaetotaxy of tergites I–XI: 6:9–11:11–14:12–15:12–15:12–15:12–15:12–15:13–16:12–16:9–12(4 tactile setae):7(4 tactile setae). Chaetotaxy of sternites II (♂): 12–15 (4 of which along anterior margin of genital opening: Fig 29), III: 18–20 (8–9 of which discal or along posterior margin of genital opening: Fig 29), IV: 10 + 4–8 discal setae, V: 12–14 + 7 discal setae, VI: 13–17 + 3–4 discal setae, VII–XI: 15–18:15–16:16–17:14–15:7; genital chamber with 2 unmodified setae, 2 median genital sacks; sternite VI without modified glandular area; chaetotaxy of sternites II-XI (♀): 9–12:13–16:11–14:12–16:14–17:16–17:16–18:14–16:12–15:7; sternites IV–VI of ♀ without discal setae; sternites III and IV (♂♀) with 4 microsetae in front of each stigma; anal cone with 2+2 setae. Chelicera (Figs 30, 42) 2.0–2.2 (♂♀) times as long as broad, palm with 5 setae, fixed and movable fingers respectively with 9–18 and 6-10 subequal teeth, *gl* ratio 0.63–0.71, spinneret absent (silk ducts not seen), rallum with 6 blades (the 2–4 distal blades finely dentate, the median ones side-by-side); serrulae interior and exterior respectively with 17–21 and 20–24 blades. Manducatory process triangular and acuminate, with 2 setae. Coxal setae: pedipalp 8–12, I 5–7, II 5–8, III 3–4, IV 6–10. Pedipalp (Figs 31–35, 43–46): trochanter 2.1–2.6 (♂) 2.3–2.5 (♀) times as long as broad, granulate, with one button-like tubercle on antiaxial face; femur 4.5–5.6 (♂) or 4.9–5.1 (♀) times as long as broad, granulate; patella 2.8–3.6 (♂) or 2.9–3.0 (♀) times as long as broad, club-shaped, weakly granulate on paraxial face of club; chela with pedicel 3.9–4.9 (♂) or 3.5–3.9 (♀) times as long as broad; hand of chela with pedicel 1.7–2.1 (♂) or 1.6–1.8 (♀) times as long as broad, ovoid, finely granulate in distal third, pedicel with hispid granulation; fixed chelal finger with 62–84 (♂♀) small, pointed contiguous teeth with dental canals (Figs 34, 45); base of fixed finger with 4–8 microtubercles; tip of fixed finger as in Figs 37 and 48, venom duct short; movable chelal finger with 66–77 (♂♀) small contiguous teeth with dental canals reaching back halfway between *b* and *sb* (Figs 34, 45); tip of movable finger as in Fig. 38; coupled sensilla *pc* in variable position, distal, proximal or at level with *sb* (Figs 36, 47); a large tubercle (sensillum?) between *b* and *sb* (Figs 36, 47); trichobothria as in Figs 33–35 and 44–46, *ib* slightly proximad *eb*, both in distal third of the hand; *est* mostly halfway between *ist* and *it*, rarely slightly proximad *it* (Fig. 46); trichobothrium *t* simple, slightly shorter than *st* and weakly bent backward; ratio of movable finger/hand of chela with pedicel 1.3–1.5 (♂) or 1.3–1.4 (♀); ratio of pedipalpal femur/movable finger 0.95–1.1 (♂♀); ratio of pedipalpal femur/carapace 1.0–1.2 (♂) or 1.1–1.2 (♀). Leg I (♂♀): femur 3.7–4.9 times as long as deep and 1.5–1.75 times longer than patella, the latter 2.5–3.1 times as long as deep, tibia 4.6–5.7 times, basitarsus 2.7–3.8, telotarsus 4.75–5.5 times as long as deep and 1.25–1.5 times longer than basitarsus, subterminal seta dentate, arolium shorter than claws, latter smooth; leg IV (♂♀) (Figs 39, 49): femur+patella 4.3–6.0 times as long as deep, ratio of femur/patella 0.55–0.67; tibia 5.6–8.1 times, basitarsus 3.1–4.4 times as long as deep, telotarsus cylindrical, not expanded, 4.3–5.8 as long as deep and 1.2–1.4 times



Figs 28-40: *Pseudoblothrus regalini* Inzaghi, 1983, male from Adro, Italy, unless otherwise stated. **28:** carapace; **29:** genital opening; **30:** right chelicera; **31:** trochanter, femur and patella, right pedipalp; **32:** patella, right pedipalp (from Ardesio, Italy); **33:** right chela, dorsal view; **34:** id., lateral view; **35:** outline of right chela with trichobothrial pattern (from Ardesio, Italy); **36:** right chela, detail of proximal dentition; **37:** apex of fixed chelal finger, lateral view; **38:** apex of movable chelal finger, lateral view; **39:** right leg IV; **40:** subdistal seta of leg IV. (Scale bar 0.5 mm: figs 28, 30-35, 39; 0.1 mm: figs 29, 36-38, 40)

longer than basitarsus; junction between femur and patella perpendicular, subterminal seta dentate (Fig. 40), arolium shorter than claws, latter smooth.

Measurements (in mm). Body length 2.8–3.1 (♂) 2.8–3.5 (♀). Carapace 0.72–0.79 × 0.48–0.62 (♂) or 0.78–0.88 × 0.53–0.63 (♀). Chelicera 0.40–0.46 × 0.185–0.22 (♂) or 0.41–0.51 × 0.20–0.24 (♀); movable finger length 0.265–0.305 (♂) or 0.28–0.34 (♀). Pedipalp: trochanter 0.38–0.48 × 0.18–0.205 (♂) or 0.44–0.54 × 0.18–0.24 (♀); femur 0.73–0.95 × 0.16–0.19 (♂) or 0.89–1.05 × 0.18–0.205 (♀); patella 0.62–0.77 × 0.20–0.25 (♂) or 0.66–0.82 × 0.23–0.285 (♀); chela with pedicel 1.22–1.53 × 0.30–0.39 (♂) or 1.26–1.60 × 0.36–0.43 (♀); hand with pedicel length 0.55–0.69 (♂) or 0.58–0.76 (♀); movable finger length 0.75–0.98 (♂) or 0.80–1.00 (♀). Leg I: femur 0.35–0.49 × 0.095–0.115 (♂) or 0.465–0.51 × 0.105–0.12 (♀), patella 0.23–0.28 × 0.085–0.105 (♂) or 0.275–0.31 × 0.11 (♀), tibia 0.32–0.43 × 0.07–0.085 (♂) or 0.405–0.47 × 0.08–0.9 (♀), basitarsus 0.16–0.23 × 0.05–0.07 (♂) or 0.23–0.255 × 0.07 (♀), telotarsus 0.235–0.295 × 0.045–0.06 (♂) or 0.31–0.33 × 0.06 (♀); leg IV: femur+patella 0.56–0.755 × 0.13–0.15 (♂) or 0.74–0.84 × 0.15–0.17 (♀), tibia 0.45–0.65 × 0.08–0.11 (♂) or 0.63–0.71 × 0.10–0.115 (♀), basitarsus 0.20–0.29 × 0.065–0.08 (♂) or 0.275–0.30 × 0.08–0.09 (♀), telotarsus 0.285–0.36 × 0.055–0.08 (♂) or 0.37–0.39 × 0.07–0.075 (♀).

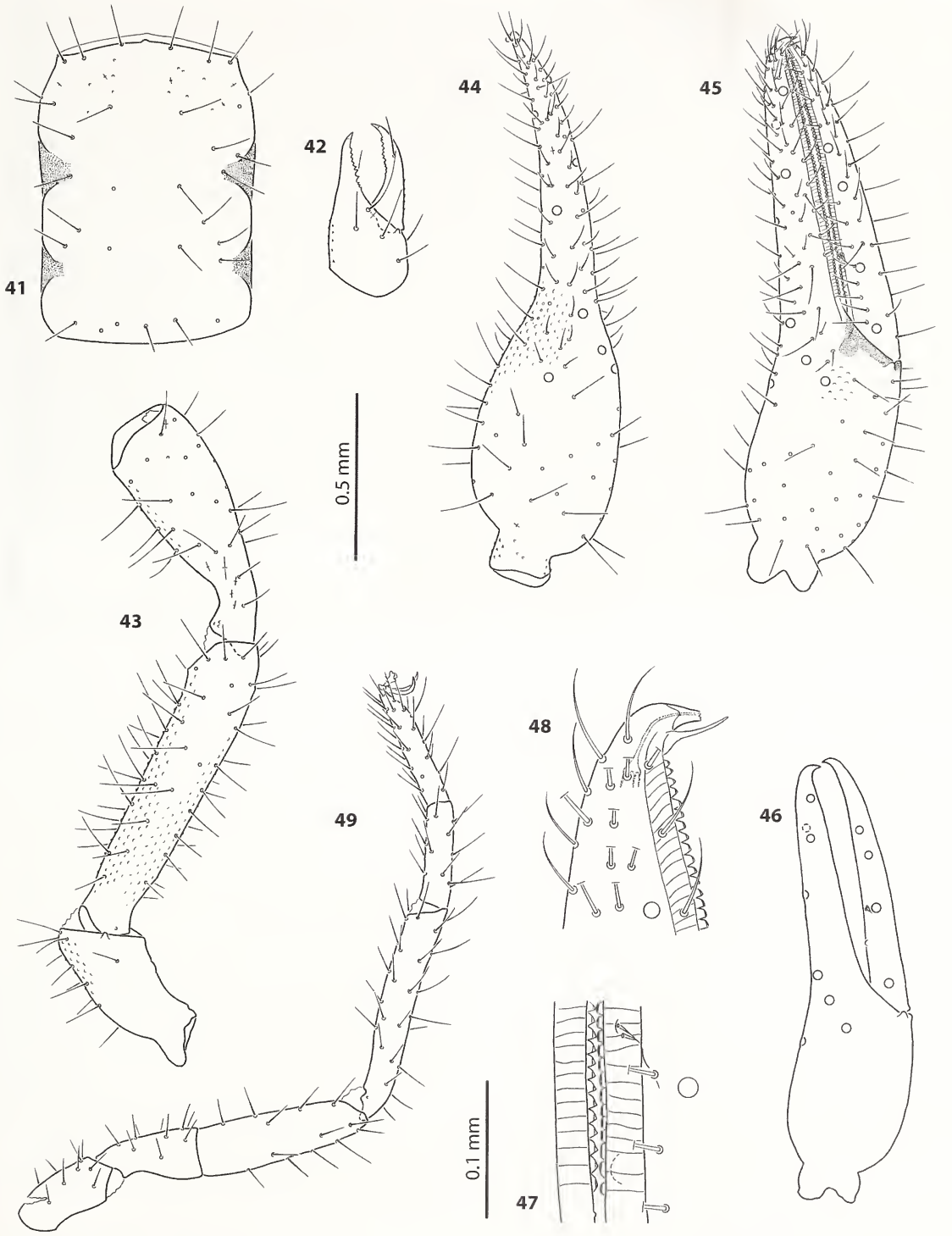
Description of tritonymph. No specimens examined: see Inzaghi (1983: 44, figs 10–12).

Remarks. The above redescription of *P. regalini* partially incorporates the original description of Inzaghi (1983), with the exception of a discrepancy concerning the pedipalpal granulation [trochanter and patella described as smooth in Inzaghi (1983), granulate here]. The highest length/breadth ratios of the pedipalps reported here (femur 5.6, patella 3.6, chela 4.9 as long as broad: see Figs 32, 35) were obtained from measurements of a male from Ardesio (Grotta della Poderizza), and are considered to form part the normal range of variation for this species. The presence of a putative new species of *Pseudoblothrus* from Mt Resegone near Lecco, Lombardy (Inzaghi *in* Gardini 2000) is still doubtful and might concern material similar to the above mentioned male of *P. regalini* from Ardesio or to the female of Piani Resinelli, which show a different position of trichobothrium *est* (Fig. 46). Mt Resegone is ca. 36 km west of Ardesio and ca. 10 km southeast of Piani Resinelli. Further material is therefore necessary to confirm the taxonomic status of these populations in the Bergamasque pre-Alps.

Key to adults of the *Pseudoblothrus* species

[The male of *P. vulcanus* Mahnert 1990, which was originally described from females, has a discal gland opening area with two patches of glandular setae on sternite VI (V. Mahnert in litt., 16.II.2015)]

1 Sternite VI of male without discal area of gland openings 2
- Sternite VI of male with discal area of gland openings 4
2 Carapace usually with 6 setae in the anterior row; sternite III with 4+4 suprastigmal setae; cheliceral palm with 5 setae; pedipalpal femur 4.5–5.6 or 6.9–8.9, patella 2.8–3.6 or 5.0–6.8 times as long as broad; length of pedipalpal fingers 0.75–1.00 or 1.35–2.05 mm; species from western and central Alps 3
- Carapace with 4 setae in the anterior row; sternite III with 3+3(4) suprastigmal setae; cheliceral palm with (5)6 setae; pedipalpal femur 6.1, patella 3.5 times as long as broad; length of pedipalpal fingers 1.125 mm; species from central Switzerland ..... *P. thiebaudi* Vachon, 1969
3 Sternite IV with 3+3 suprastigmal setae; species of large size, with pedipalps more slender: femur 1.34–2.24/0.19–0.27 mm (6.9–8.9×), patella 1.22–2.12/0.235–0.32 mm (5.0–6.8×), chela 2.13–3.18/0.31–0.44 (6.0–7.5×); fixed and movable chelal fingers respectively with 100–150 and 91–153 teeth; species from SE France and NW Italy (Piedmont) .. *P. peyerimhoffi* (Simon, 1905)
- Sternite IV with 4+4 suprastigmal setae; species of middle size, with pedipalps less slender: femur 0.73–1.05/0.16–0.205 mm (4.5–5.6×), patella 0.62–0.82/0.20–0.285 mm (2.8–3.6×), chela 1.22–1.60/0.30–0.43 mm (3.5–4.9×); fixed and movable chelal fingers respectively with 62–84 and 66–77 teeth; species from N Italy (Lombardy) ..... *P. regalini* Inzaghi, 1983
4 No eyes; species of large size, with pedipalps more slender: femur 1.10–2.08/0.17–0.27 mm (6.0–8.5×), patella 0.89–1.88/0.21–0.35 mm (3.8–6.2×), hand 0.71–1.42/0.29–0.54 mm (2.2–2.9×), finger 1.15–1.97 mm; species from continental Europe 6
- Four reduced eyes (with tapeta); species of medium size, with pedipalps less slender: femur 0.82–0.94/0.16–0.17 mm (4.9–5.7×), patella



Figs 41-49: *Pseudoblothrus regalini* Inzaghi, 1983, female from Grone, Italy, unless otherwise stated. **41:** carapace; **42:** right chelicera; **43:** trochanter, femur and patella, right pedipalp; **44:** right chela, dorsal view; **45:** id., lateral view; **46:** outline of right chela with trichobothrial pattern (from Lecco, Piani Resinelli, Italy); **47:** right chela, detail of proximal dentition; **48:** apex of fixed chelal finger, lateral view; **49:** right leg IV. (Scale bar 0.5 mm: figs 41-46, 49; 0.1 mm: figs 47-48)

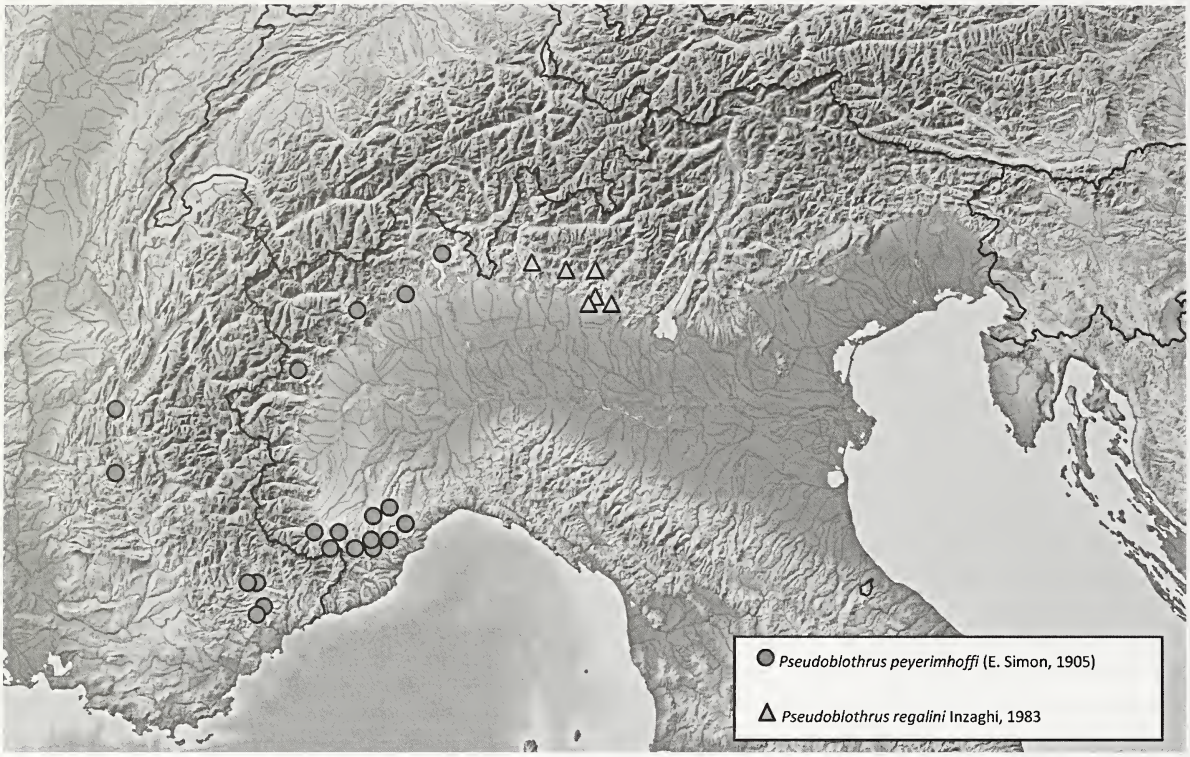


Fig. 50: Distribution map of *Pseudoblothrus peyerimhoffi* (Simon, 1905) (circles) and *P. regalini* Inzaghi, 1983 (triangles)

0.68–0.77/0.21–0.23 mm (3.1–3.5×), hand 0.58–0.74/0.34–0.37 mm (1.7–2.0×), finger 0.85–0.98 mm; species from the Azores 5

5 Pedipalps smaller and less slender: femur 0.82–0.85 mm (4.9–5.0×), chela 1.37–1.41 mm (4.0–4.1×); ratio telo/basitarsus of leg I 1.50–1.64, of leg IV 1.36–1.42; species from the Azores: Sao Jorge Isl. . . . . *P. oromii* Mahnert, 1990

- Pedipalps larger and more slender: femur 0.92–0.94 mm (5.4–5.7×), chela 1.54–1.59 mm (4.3–4.5×); ratio telo/basitarsus of leg I 1.26–1.37, of leg IV 1.16–1.31; species from the Azores: Terceira Isl. . . . . *P. vulcanus* Mahnert, 1990

6 Carapace with 6 setae in the posterior row; pedipalpal femur and hand smooth; smaller: length of pedipalpal femur 1.10–1.12 mm, length of finger 1.15–1.23 mm; species from France and Switzerland 7

- Carapace with 4 setae in the posterior row; pedipalpal femur and hand granulate; larger: length of pedipalpal femur 1.77–2.08 mm, length of finger 1.63–1.97 mm; species from Crimea 8

7 Sternite VI with 3 patches of glandular setae; carapace with 6 setae in the anterior row; sternites III and IV with 3+3 suprastigmal setae each; pedipalpal chela 5.5–5.9 times as long as broad; species from Swiss and French Jura Mountains. . . . . *P. strinatii* Vachon, 1954

- Sternite VI with 2 patches of glandular setae; Carapace with 4 setae in the anterior row; sternites III and IV with 4+4 suprastigmal setae each; pedipalpal chela 6.4 times as long as broad; species from central Switzerland . . . . . *P. infernus* Mahnert, 2011

8 Species of larger size, with pedipalps more slender: length of femur 2.08 mm (8.0–8.5×), length of patella 1.81–1.88 mm (6.2–6.3×), length of hand 1.41–1.42 (3.2×) . . . . . *P. roszkovskii* Redikorzev, 1918

- Species of smaller size, with pedipalps less slender: length of femur 1.77–1.95 mm (7.0–7.5×), length of patella 1.52–1.74 mm (4.7–5.4×), length of hand 1.07–1.25 mm (2.3–2.9×). . . . . *P. ljovuschkini* Krumpál, 1984

Acknowledgements

I express my sincere thanks to all the collectors, especially Enrico Lana (Chivasso, Italy), for the material kindly do-

nated to me during the last thirty years. Volker Mahnert (Muséum d'Histoire naturelle, Geneva), Juan A. Zaragoza (Departamento de Ecología, Universidad de Alicante) and Carlo Giusto (Genova) kindly supplied helpful comments on the manuscript and (V. M.) information about paratypes of *P. ljovuschkini* in the Muséum d'Histoire naturelle, Geneva. Emanuele Bruzzone (D.I.S.T.A.V., Università di Genova) provided invaluable expertise in digitizing the plates of drawings. Two anonymous reviewers improved the text with useful comments.

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The covering setae of ground spiders (Araneae: Gnaphosidae)

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doi: 10.5431/aramit4904

Abstract. Previous study of the setae covering the opisthosoma of ground spiders shows that the morphology of the covering setae is genus-specific. The present study pursues the description of covering setae across the whole Gnaphosidae family using SEM. A detailed morphology of the setae of ground spiders (Araneae, Gnaphosidae) is presented. The six major types of covering setae recognized among gnaphosid spiders are squamose, plumose, lanceolate, pinnate, arborate and sicate setae. Squamose setae are characteristic for *Micaria lenzi* and *Nauhea tapa*. Plumose setae are more common in ground spiders and occur in the genera *Drassodes*, *Haplodrassus*, *Anagraphis*, *Nodocion*, *Zelotes* and the species *Berlandina caspica*, *Nomisia aussereri*, *Minosiella intermedia*, *Sosticus loricatus*, *Leptodrassus memorialis*, *Intruda signata*, *Parasyrisca caucasica*, *Scopoides catharius*, *Echemoides tofo*, *Zimiromus medius*, *Encoptarthria echemophthalma*, *Apodrassodes trancas*, *Apopyllus silvestri*, *Hemicloea sundevalli*, *Zelanda erebus*, *Orodrassus assimilis*, *Callilepis nocturna* and *Synaphosus turanicus*. The species *Matua valida*, *Anzacia gemmea*, *Hypodrassodes maoricus*, *Homoeothele micans* and *Scotophaeus blackwalli* have lanceolate setae. Spiders of the genus *Gnaphosa* have pinnate setae. *Fedotovia uzbekistanica* has arborate setae. The species *Cesonia bilineata*, *Herpyllus propinquus*, *Litopyllus temporarius*, *Aphantaulax seminigra* and *Kishidaia conspicua* have sicate setae. Some genera, such as *Drassodes* and *Synaphosus*, have a combination of different types of setae on their opisthosoma, whereas others, like *Eilica* sp., *Laronius erawan*, *Urozelotes rusticus*, have no covering setae on their opisthosoma at all. This study reveals the existence of different types of covering setae and provides a set of characteristics important for the classification and phylogenetic analysis of Gnaphosidae.

Keywords: arborate, lanceolate, pinnate, plumose, sicate, squamose setae

All ground spiders possess setae that cover their bodies. Ovtsharenko (1983, 1985, 1989) and after that Murphy (2007) recognized 10 different types of setae on the cuticle of ground spiders. Setae have different morphologies and diverse functions, depending on their location on the body (Ovtsharenko 1985, 1989). Aculeate setae are the most common type of setae on the cuticle. These setae are widely distributed over the spider's body. The majority of these setae are sensory organs or mechanoreceptors (Murphy 2007). Covering setae are located mostly on the abdomen, dorsally, ventrally and laterally, and may also cover the cephalothorax, legs, pedipalps and spinnerets. Covering setae have no connection with sensory receptor cells, they have no sensory function (Townsend & Felgenhauer 1998a, 1998b, 1999, 2001, Foelix 2011), and are identified by the following characteristics: (a) the covering setae rest in the shallow depression or small elevation of the cuticle, (b) the pedicel is bent at an obtuse angle where it emerges from the socket, (c) the main axis of the setae is parallel to the surface of the spider's body, and (d) the trunk of the setae has appendages.

The covering setae are of special interest. Lehtinen was among the first who noted the importance of these cuticular structures for spider classification (Lehtinen 1967, 1975a, 1975b). Thus, he called the covering setae 'feathery hairs' on the tibia of *Micaria pulicaria* (Lehtinen 1975b). Hill (1979) and Townsend & Felgenhauer (1998a, 1998b, 1999) made a significant contribution to our understanding of the diversity of the shapes of these cuticular structures, which they called 'scales'. Studies of ground spiders (Araneae: Gnaphosidae) demonstrate that they are greatly varied in shape and are genus-specific (Ovtsharenko 1983, 1985, 1989, Murphy 2007). The value of scales for classification and establishing evolutionary relationships were demonstrated for jumping spiders (Hill 1979) and lynx spiders (Townsend & Felgenhauer 2001). The wide diversity of scales and their value for phylogenetic analysis were used for the reconstruction of the phylogeny of araneomorph spiders (Griswold et al. 2005, Ramírez 2014). However, knowledge about the diversity of the covering setae among gnaphosid spiders is far from complete and still has to be addressed. As Murphy (2007: 31) said: "A serious study of spider setae may yet reveal much of interest".

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submitted 12.11.2014, accepted 21.5.2015, online: 10.6.2015

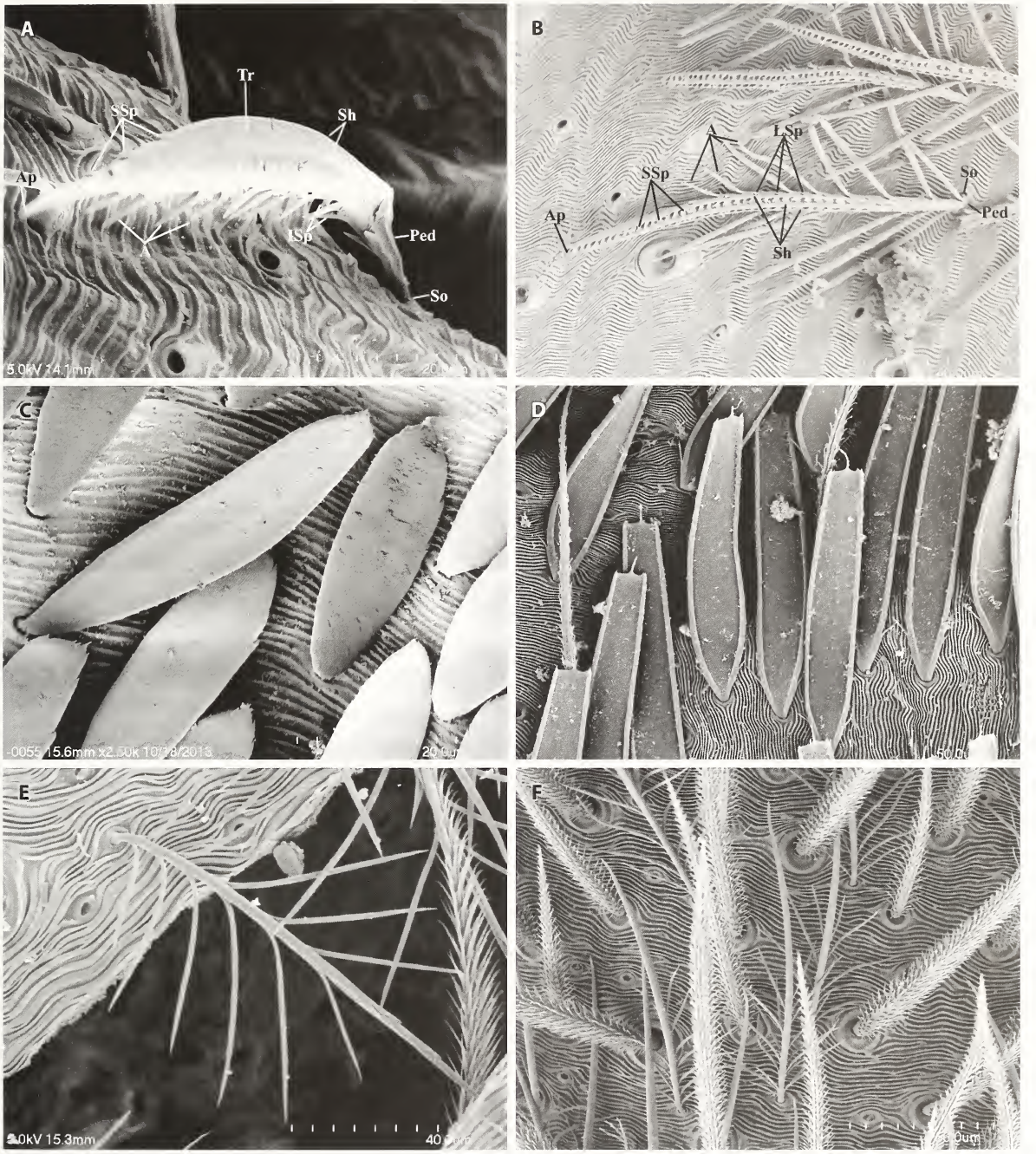

Fig. 1: External features of covering setae; squamose (c and d), sicate (a) and plumose (b, e and f) setae on abdomen of gnaphosid spiders. **A.** *Cesonia bilineata*; **B.** *Anagraphis sp.*; **C.** *Micaria lenzi*; **D.** *Nauhea tapa*; **E.** *Echemoides tofo*; **F.** *Drassodes lapidosus*; A – appendages, Ap – apex, Ped – pedicel, ISp – inferior spines, SSp – superior spines, Sh – shafts, So – socket, Tr – trunk.

In this study, we use the term 'covering setae' based on the following reasoning: 1. A scale is thin, flat plate, which is the most common shape for these structures among jumping and lynx spiders. However, this type of shape is comparatively rare among gnaphosids. Ground spiders often have feather-shaped setae, far from being a flat plate. 2. The term feathery hair was first used by Lehtinen for these structures (Lehtinen 1975b, Fig. 7, image 12). 3. In studies of ground spiders (Araneae: Gnaphosidae) the term 'se-

tae' was traditionally used for these structures (Ovtsharenko 1983, 1985, 1989, Ovtsharenko et al. 1994, 1995, Ovtsharenko & Platnick 1995, Platnick et al. 2001, Murphy 2007). Thus, in the article on spiders of the genus *Synaphosus* the authors wrote that the abdomen of the spider is "covered by thick, plumose setae bearing 4-7 pairs of appendages originating from ventral surface of setae (Figs 5, 6)" (Ovtsharenko et al. 1994, p. 3).

Materials and methods

Specimens were examined with a Hitachi S-4700 Field Emission SEM at the American Museum of Natural History (New York). The cut-off abdomen was dehydrated in acetone, critically point dried in carbon dioxide, mounted with double-sided sticky carbon tape, and sputter coated using the necessary materials. The resulting images were combined using Photoshop.

Setae terminology follows Simon (1893), Berland (1919), Lehtinen (1975a, 1975b), Platnick (1975), Hill (1979), Ovtsharenko (1983, 1985, 1989), Townsend & Felgenhauer (2001) and Murphy (2007). Collections examined: AMNH - American Museum of Natural History, New York, USA; NMNZ - National Museum of New Zealand Te Papa Tongarewa, Wellington, New Zealand; OMD - Otago Museum, Dunedin, New Zealand; OPC - V. Ovtsharenko personal collection; SAM - South Australian Museum, Adelaide, Australia; ZDUC - Zoological Department of the University of Canterbury, Christchurch, New Zealand; ZISP - Zoological Institute Saint Petersburg, Russia.

The following species were studied (locality and collection included): *Anzacia gemmea* (Dalmas, 1917) [NEW ZEALAND: Kaikoura, January, 1961; OMD]; *Anagraphis* sp. [KAZAKSTAN: Atyrau District, Ustyurt Natural Reserve, Ustyurt Plateau, village Kemderlie, May 20, 1989, coll. I. I. Ibraev and A. A. Zyuzin; OPC]; *Apodrassodes trancas* Platnick & Shadab, 1983 [ARGENTINA: El Bolsón, Rio Negro, September 1962, coll. A. Kovacs; AMNH]; *Apopyllus silvestri* (Simon, 1905) [ARGENTINA: Epuyén, Chubut, June 12, 1962, coll. Andor Kovacs; AMNH]; *Berlandina caspica* Ponomarev, 1979 [AZERBAIJAN: village Dubendy, May 21, 1977, coll. Dunin; OPC]; *Cesonia bilineata* (Hentz, 1847) [USA: Arkansas, Logan Co., mountain Magazine, Mossback Ridge Bluff, July 20, 1990, pitfall trap, coll. B. Leary; AMNH]; *Drassodes lapidosus* (Walckenaer, 1802) [AZERBAIJAN: Pirgulu State Reserve, 1300 m, May 21, 1984, coll. D. Logunov; OPC]; *Echemoides tofo* Platnick & Shadab, 1979 [CHILE: Coquimbo, Llano de la Higuera, September 29, 1980, coll. L. E. Péna; AMNH]; *Encoptarthria echemophthalma* (Simon, 1908) [AUSTRALIA: Belair Natural Park, 300 m S Lower Waterfall, 35°01'S, 138°43'E, pitfall, November 28-December 5, 1994, coll. E. G. Matthews, J. A. Forrest; SAM]; *Fedotovia uzbekistanica* Charitonov, 1946 [KAZAKHSTAN, Muyunkum District, 51 km of highway Mirnyi-Khantau, June 8-9, 1990, coll. A. A. Fedorov; ZISP]; *Gnaphosa muscorum* (L. Koch, 1866) [RUSSIA: Chita Region, Sokhondo Natural Reserve, river Upper Bukukun, pitfall trap, July 21, 1990, coll. S. Danilov; OPC]; *Gnaphosa taurica* Thorell, 1875 [KIRGHIZSTAN, Kirghiz-Ata gorge, northern slope, June 11, 1985, coll. A. A. Zuzin, OPC]; *Haplodrassus dalmatensis* (L. Koch, 1866) [AZERBAIJAN: Kashkachay vill., elev. 1000 m, June 24, 1977, coll. Dunin; OPC]; *Haplodrassus soerenseni* (Strand, 1900) [RUSSIA: Altai, Turochak District, Altai Mountains, pine forest, pitfall trap, coll. S. B. Ivanov; OPC]; *Homoeothele micans* Simon, 1908 [AUSTRALIA: 3.1 km WNW Mount Lindsay, 27°01'09"S, 129°51'01"E, Pitjantjatjara lands Survey WAT 03, pitfall trap, October 1996; SAM, N 9061-2]; *Hypodrassodes maoricus* Dalmas, 1917 [NEW ZEALAND: Wellington, Karori, inside house, November 8, 1995, coll. C. Palma; NMNZ]; *Intruda signata* (Hogg, 1900) [NEW ZEALAND: Auckland, Beechlands, 36°53'S, 174°46'E, Jan. 1951, coll. J. Campbell; OMD]; *Leptodrassus memorialis* Spassky, 1940 [RUSSIA: Rostov Region, Zavetninskye district, 4 km S.-E. vil. Fedoseevka, clay riverbank, June 15, 1973, coll. Ponomarev; OPC]; *Leptodrassus* sp. [KAZAKHSTAN: Atyrau, Ustyurt Natural Reserve, Usturt Plateau, Baskorgan wells, May 28, 1989, coll. A.A. Raikhapov, S. I. Ibraev; OPC]; *Litopyllus temporarius* Chamberlin, 1922 [USA: Black Rock Forest, Cornwall, NY, 41.42267°N, 74.03039°W, July 5, 2009, coll. V. Ovtsharenko, B. Zakharov; OPC]; *Matua valida* Forster, 1979 [NEW ZEALAND: Arrowtown, December 3, 1969, under stone, coll. R. R. Forster; OMD]; *Micaria lenzi* Bösenberg, 1899 [RUSSIA: Magadan Region, Tenkinskye district, Sibit-Tiellakh village, May 15, 1983, coll. S. Buhkalo; OPC]; *Minosiella intermedia* Denis, 1958 [TURKMENISTAN: Repetek, April 6, 1981, coll. V. A. Krivohatsky; OPC]; *Nauhea tapa* Forster, 1979 [NEW ZEALAND: Logan Burn,

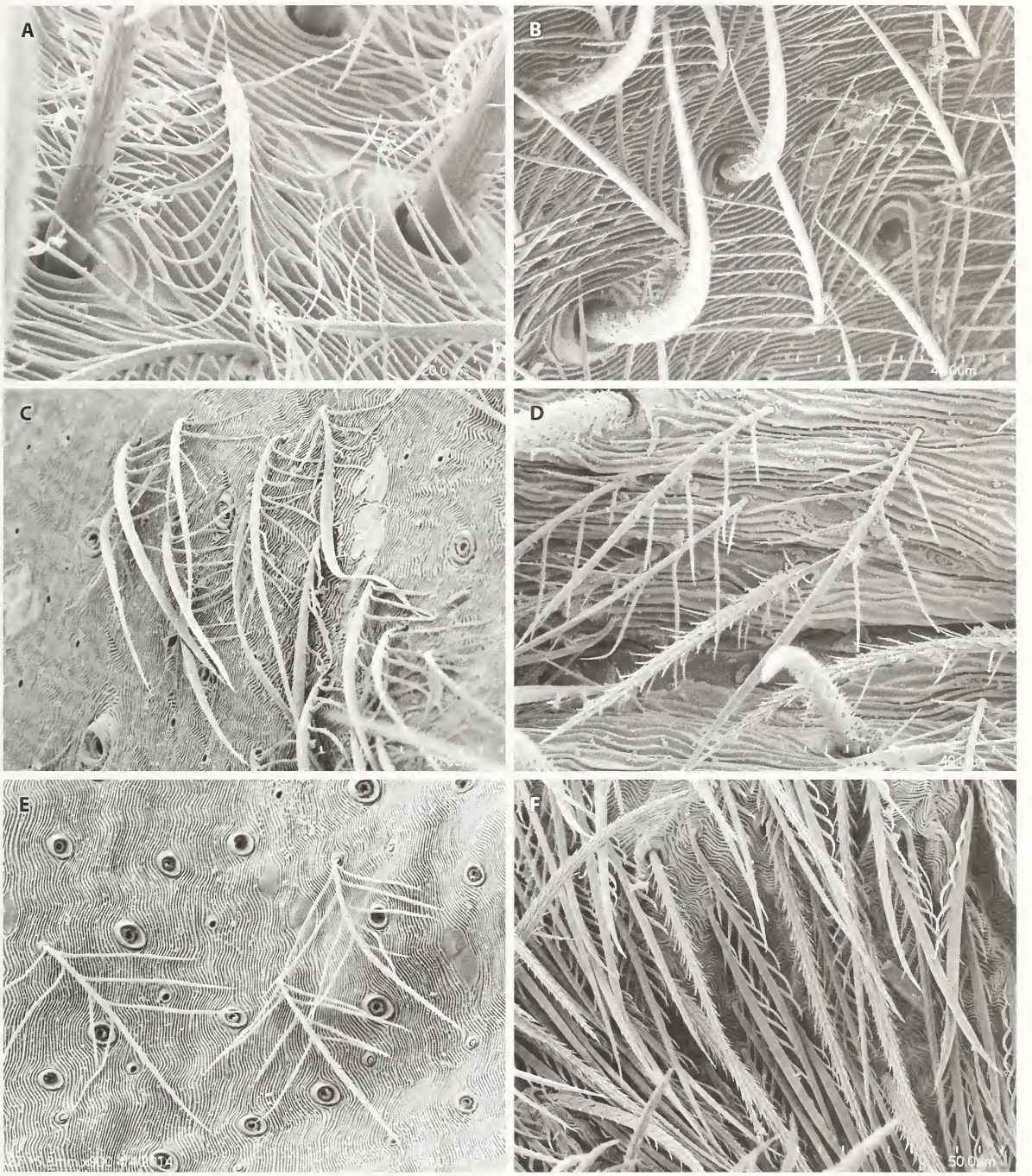

Fig. 2: Plumose setae on the abdomen. **A.** *Berlandina caspica*, **B.** *Nomisia aussereri*, **C.** *Haplodrassus dalmatensis*, **D.** *Sosticus loricatus*, **E.** *Leptodrassus memorialis*, **F.** *Synaphosus turanicus*

11-23 February, 1983, 900 m, pitfall trap, coll. B. I. P. Barratt; OMD]; *Nodocion eclecticus* Chamberlin, 1924 [USA: Tucson, Arizona, coll. O. Bryant; AMNH]; *Nodocion mateonus* Chamberlin, 1922 [USA: Lake Co.: Albert Lake, July 2, 1961, coll. B. Malkin; AMNH]; *Nomisia aussereri* (L. Koch, 1872) [AZERBAIJAN: Kuba, Tenshalti, September 26, 1984, coll. unknown; OPC]; *Orodrassus assimilis* (Banks,

1895) [USA: Oregon, Willow Creek Camp, Warner Mountains, Lake Co., June 22, 1952, coll. B. Malkin; AMNH]; *Parasyrisca caucasica* Ovtsharenko, Platnick & Marusik, 1995 [RUSSIA: Caucasus, Krasnodar Region, Caucasian Reservation, Mountain Mramornaia, 2500 m, July 27, 1975, coll. V. I. Ovtsharenko; OPC]; *Pterotricha* sp. [UZBEKISTAN: Bukhara region, 70 kn W of Utch-Kuduk, 30 km SW of the village Minbulak, sand desert, coll. D. V. Logunov; OPC]; *Pterotricha strandi* Spassky, 1936 [TURKMENISTAN: Repetek, June 14, 1979, coll. V. A. Krivokhatsky; OPC]; *Scopoides catharius* (Chamberlin, 1922) [USA: California, 1-2 mi W of Lane Pine, Inyo Co., April 27, 1960, coll. W. J. Gertsch, Ivie and Schrammel; AMNH]; *Scotophaeus blackwalli* (Thorell, 1871) [USA: California, Glendale, October 15, 1951, coll. Ted Tice; AMNH]; *Sosticus loricatus* (L. Koch, 1866) [UZBEKISTAN: Tashkent district, village Toitepa, June 18-30, 1981, coll. N. M. Kudrina; OPC]; *Synaphosus turanicus* Ovtsharenko, Levy & Platnick, 1994 [KAZAKHSTAN, Atyrau, District, Ustyurt Natural Reserve, Ustyurt Plateau, Baskorgan wells, May 25, 1989, coll. A. A. Raikhapov, S. Ibraev, V. Ovtsharenko; OPC]; *Zelanda erebus* Foster, 1979 [NEW ZEALAND: Gainesville; ZDUC]; *Zelotes lasalanus* Chamberlin, 1928 [USA: Arizona, Tucson, coll. O. Bryant; AMNH]; *Zimiromus medius* (Keyserling, 1891) [BRAZIL: S. Paulo, S. Bocaina, 1960 m, S. Jose Barreiro, November 1968, coll. M. Alvarenga; AMNH].

Results

Almost all ground spiders (Araneae: Gnaphosidae) have covering setae. Some species possess a combination of different types of setae on their body. Density of the setae varies on the spider's body. Some species have few setae loosely scattered over the dorsal side of the abdomen. In other species, setae entirely cover the opisthosoma, cephalothorax and legs, and create the shingle-like overlapping coverage that may be iridescent as in *Nauhea tapa* (Fig. 1D). The covering setae rest in a shallow depression of the cuticle that is slightly elevated above the integument surface or located on small tubercle of the cuticle. The pedicel of the seta is bent at an obtuse angle after it emerges from the socket on the cuticle. As a result of this bending, the main axis of the setae is parallel to the surface of the spider's body (Fig. 1A, B).

Setae have a comparatively short pedicel bent on one side, and an apex – on the other side. The apex may be sharp, flattened, or rounded (Fig. 1C, D). In *Gnaphosa* the apex bifurcates (Fig. 6E). The trunk of the setae consists of fused shafts. Often there are three shafts that create ridges of the trunk (Fig. 1A, B). Following Hill (1979), short triangular outgrowths are defined as spines. There are superior spines (SSp) that are located on the upper surface of the trunk, lateral spines (LSp) on both sides, and inferior spines (ISp) on the side of the trunk that faces the body surface (Fig. 1A, B). The inferior spines often have a hook-like shape and, probably, provide a connection between the seta and the body surface (Murphy 2007). Setae may also have long outgrowths called appendages (A) (Fig. 1A, B). Depending on the shape of the setae shaft and types of accessory structures, there are six major types of covering setae among gnaphosid spiders: squamose, plumose, lanceolate, pinnate, arborate and sicate.

Squamose setae are flat and broad. They are comparatively short. They may bear some accessory structures and may have a spinous apex. Usually, this type of seta creates a dense, iridescent coverage of the spider's abdomen and cephalothorax (Fig. 1C, D). Squamose setae are characteristic of small ground spiders: *Micaria* and *Nauhea*. Thanks to the iridescent squamose setae these spiders have a metallic blue to green colour. *Micaria* demonstrates the diversity of squamose setae, which take many forms and may or may not have proximal appendages. The sides and tips of the setae are serrated. Murphy called this type "uncinate squamose setae". These setae show variation in size and shape. The side of some setae which face towards the body bears hook-like inferior spines (Murphy 2007). The tip of the setae may be serrated or have a sharp spike (Fig. 1C). Murphy thought that "uncinate squamose setae" are a characteristic feature of *Micaria* (Murphy 2007). In the New Zealand spider *Nauhea tapa* the pedicel of the seta proximally bears one or two pairs of appendages. The tip of the setae is wide, serrated, and with a sharp terminal spike (Fig. 1D).

Plumose setae are bilateral and look like a feather. Lehtinen (1967) called this type of seta a "feathery hair". Later he came to the conclusion that all types of feathery setae are adaptations of a setal structure that has appeared many times independently and may be regarded as different modifications of the plumose seta type (Lehtinen 1975b, see Fig. 7.12). Thus, we adopt the term "plumose setae" as the basic name for all variations of this type of setae. These

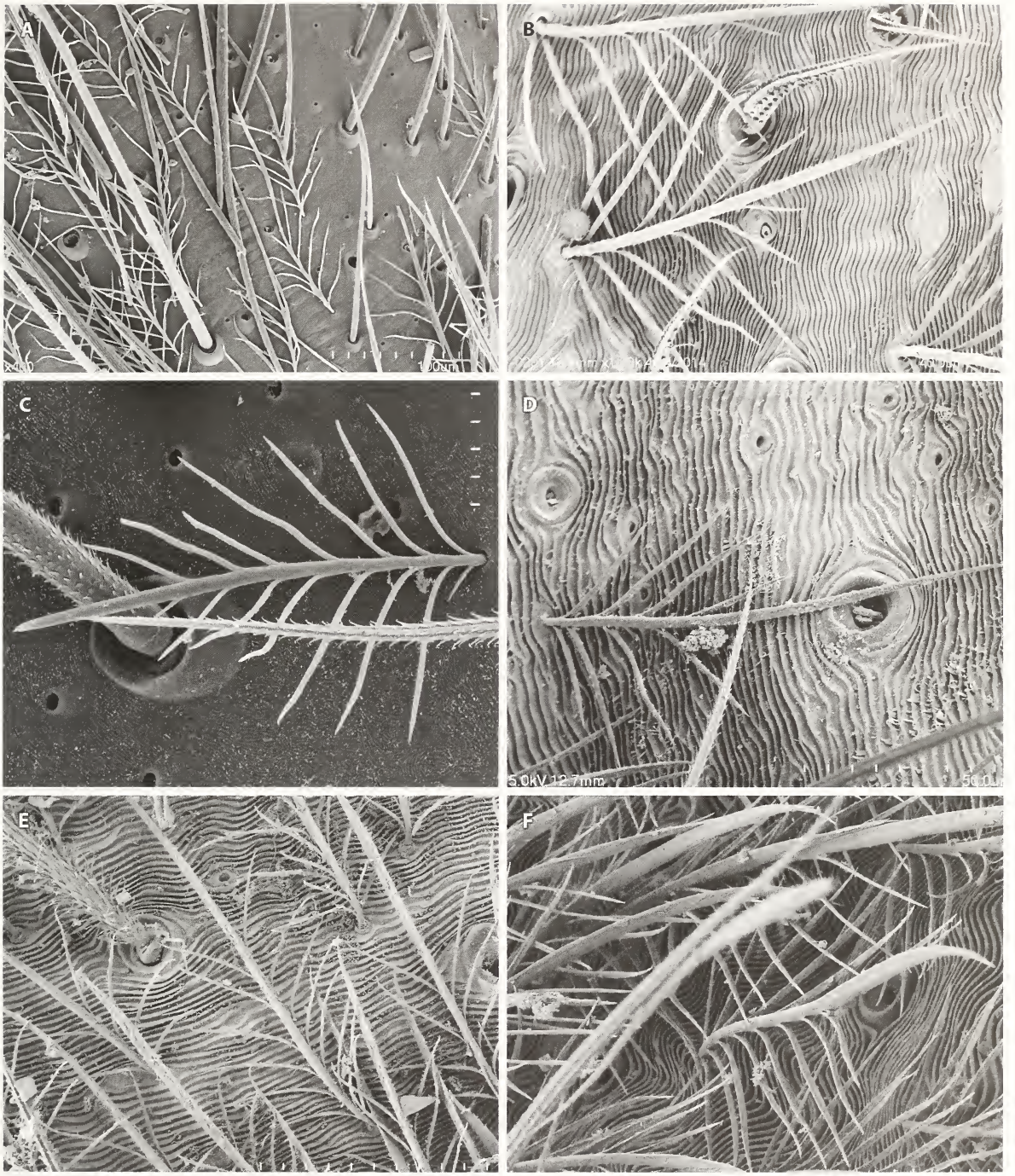

Fig. 3: Plumose setae on the abdomen (B, D, E, F), cephalothorax (C), and legs (A). **A.** *Intruda signata*, **B.** *Zimiromus medius*, **C.** *Encoptarthria echemophthalma*, **D.** *Apodrassodes trancas*, **E.** *Apopyllus silvestri*, **F.** *Minosiella intermedia*

setae have a long narrow trunk, sharp at the apex. The comparatively long appendages are branched from both sides of the trunk. The appendages may be set along the whole length of the trunk, or only on a part of it, usually the proximal third of the trunk length. The position and length of appendages are also greatly varied and may provide significant features for the spiders' classification (Figs 2, 3, 4). The middle part

of the trunk is enlarged, whereas its tip is sharpened. Appendages are set in two rows on the lateral sides of the trunk. The total number of appendages is genus-specific and varies from 2 to 44. The appendages may be long, slender, and sharp at the tip, or enlarged in their middle part, or clavate, i.e. enlarged at the tip. As a rule, appendages are more or less of the same length. However, there are exceptions. In these cases, the longest appendages are situated at the base of the trunk, and the shortest ones closer to its tip. The setae are immovably attached to the body surface on the cuticular elevation that has fine longitudinal stripes. The trunk of the setae bends proximally. This position and their immovable attachment are characteristic for covering setae only. All other setae are at a right angle or significantly far away from the integument. This suggests that plumose setae are mostly covering structures, have a protective function for the spiders' integumentary system, and do not have a sensory function (Foelix 2011). They are always present on the dorsal side of opisthosoma. They may create a continuous coverage or may be loosely distributed over the body surface (Ovtsharenko 1985).

The plumose setae of *Berlandina*, *Nomisia*, *Minosiella* and *Pterotricha* have lateral appendages along almost their entire length. The upper part of the setae that have no appendages may be only $^1/_4$-$^1/_5$ of its length as in *Nomisia* (Fig. 2B), *Minosiella* (Fig. 3F) and *Pterotricha* (Fig. 4D), or even less, as in *Berlandina* (Fig. 2A) (Ovtsharenko 1985). The number of appendages is also different. *Minosiella intermedia* has 11-18 appendages, *Pterotricha strandi* – 23-38. In *Nomisia*, it is 10-20, whereas in *Berlandina* it is 30-44 appendages or 15-22 pairs. The structure of the setae may change, depending on the body part. The abdominal setae of *Berlandina*, for example, have 30-32 appendages; setae on the carapace may have up to 44 appendages. *Nomisia* has setae with 10-12 pairs of appendages on its abdomen, 10-16 pairs on its carapace, and 10-20 pairs on the legs. In all these genera, the plumose setae create a dense coverage that completely covers all of the spider's body (Ovtsharenko 1985).

Species of the genera *Haplodrassus* (Fig. 2C) and *Drassodes* (Fig. 1F) have at the tip a clear part of their plumose setae two times longer than its base, which bears lateral appendages. The number of appendages varies. *Haplodrassus dalmatensis* has 8-14 appendages (Fig. 2C), *Haplodrassus soerenseni* has 8 appendages. *Haplodrassus signifier* has from 7 to 10 appendages (Ovtsharenko 1985, 1989). The number of appendages in this species is different on both sides of the setae's trunk. Setae on one side may have one or even three fewer appendages than on the other side. Often, if on one side it is even, then on the other it is uneven (Ovtsharenko 1985). The plumose setae of *Drassodes* vary in number from 8 to 14, but the most common is 10 (Fig. 1F).

In *Sosticus* (Fig. 2D) and *Leptodrassus* (Fig. 2E) the tip part is equal or only a little longer than the base with its appendages attached. *Sosticus* has 8-14 appendages. These appendages are of different lengths. The longest appendages are in the middle part of the trunk. *Leptodrassus memorialis* has 8-11 appendages. The tip of the setae is laterally serrated. *Intruda signata* has plumose setae with 9 appendages at the base of the trunk; 4 appendages on one side and 5 appendages on the other side (Fig. 3A).

Plumose setae of *Anagraphis* have 12-15 appendages. The appendages are not organized into pairs. Their number on opposite sides of the trunk is different. Usually, if on one side there are six appendages, the other side has eight. Beside that the setae of *Anagraphis* spiders have two rows of superior spines (SSp) and lateral spines (LSp) along the total length of the trunk (Fig. 1B). Plumose setae on the abdomen of *Nodocion meteonus* possess 12 long appendages, occupying almost half of the trunk, and 5-6 long spines distributed on the distal part of the setae; all trunk and appendage setae have fine, longitudinal ridges (Fig. 4A). In *Parasyrisca caucasica* on the abdomen there are plumose setae with 13 appendages; all appendages have different lengths (Fig. 4C). Plumose setae on the abdomen of *Scopoides catharius* have 5-15 appendages, they occupy less than half of the proximal part of the trunk; the distal part of the trunk is coved by short spines and look like scales (Fig. 4F). Plumose setae of *Echemoides tofo* have 9-11 appendages. Their number on both sides may be different and vary from 4 to 6. All of these appendages are located at the proximal $^1/_3$ of the trunk. The SSp are distributed along the total length of the trunk from the pedicel to the apex (Fig. 1E). *Zimiromus medius* has plumose setae with 10 appendages. Appendages are long and are flattened in a dorso-ventral direction. The apex of the trunk is sharp. Superior and lateral spines are also present (Fig. 3B). *Encoptarthria echemophthalma* has plumose setae with 7-8 pairs of proximal appendages, the distal part of the trunk is short, less than $^1/_3$ of the trunk (Fig. 3C). *Apodrassodes*

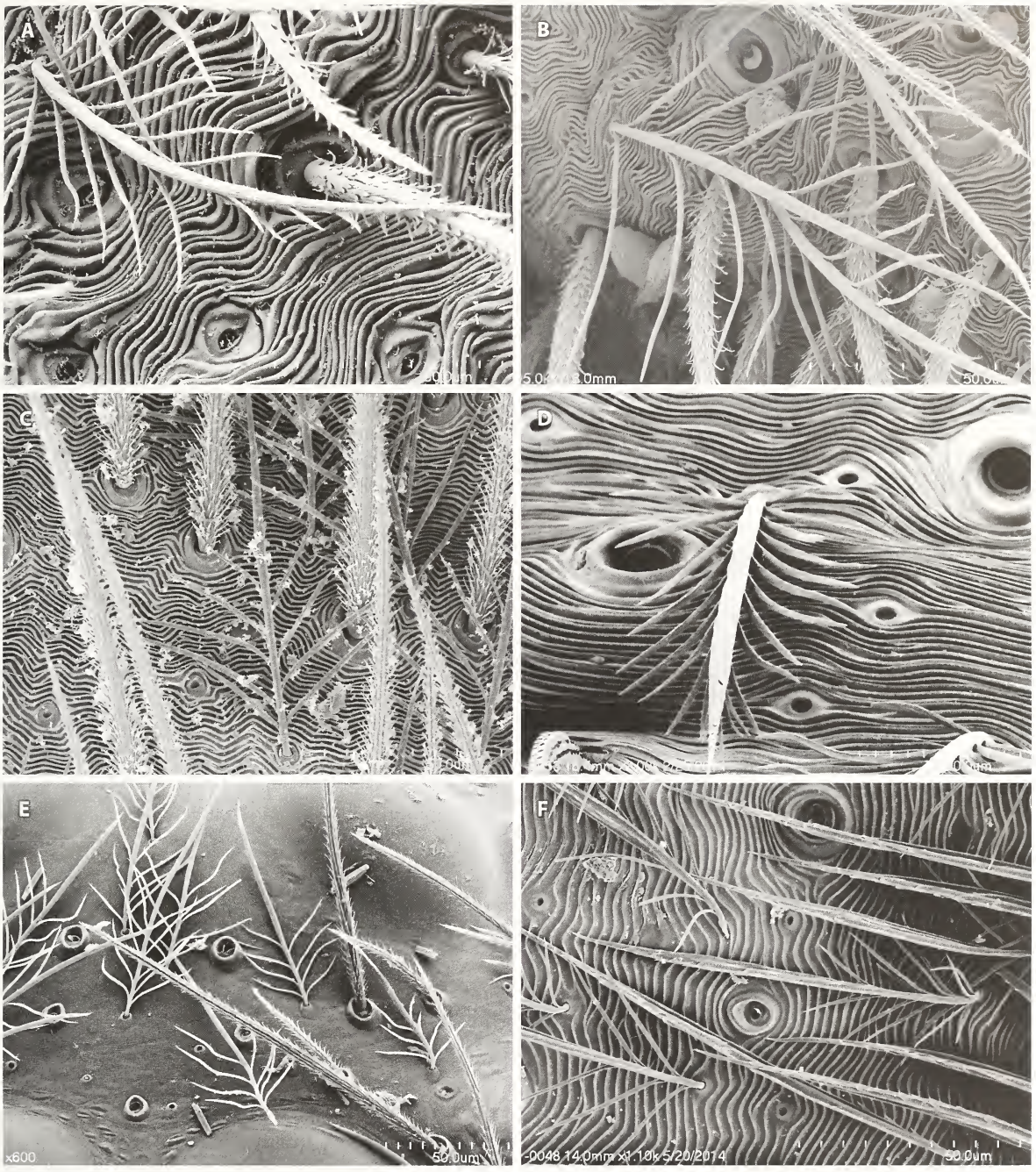

Fig. 4: Plumose setae on the abdomen (A, B, C, D, F) and cephalothorax (E). **A.** *Nodocion meteonus*, **B.** *Orodrassus assimilis*. **C.** *Parasyrisca caucasica*, **D.** *Pterotricha strandi*, **E.** *Zelanda erebus*, **F.** *Scopoides catharius*

trancas has plumose setae with 4 pairs (total amount of appendages 8) of appendages symmetrically set on the proximal $^{1}/_{3}$ of the trunk (Fig. 3D). *Apopyllus silvestri* has plumose setae with 6-8 appendages on the proximal $^{1}/_{3}$ of the trunk. The distal $^{2}/_{3}$ of the trunk is flattened (Fig. 3E). *Hemicloea sundevalli* has plumose setae with 4-5 proximal appendages on the base of the trunk. In *Zelanda* there are 4 pairs of proximally situated appendages (Fig. 4E). In *Orodrassus assimilis* the plumose setae possess 4 pairs of appendages, the trunk of the setae is smooth, serrated apically (Fig. 4B). Some genera have a reduced number of covering

setae. These spiders may have covering setae only on the abdomen and the legs, most commonly on their femur. As a rule, the number of appendages on these setae varies from 0 to 6. In the case that appendages are absent the trunk remains present on the cuticle. Thus, the plumose setae of the Palaearctic species *Callilepis nocturna* have 4-6 appendages of different lengths on their base (Ovtsharenko 1985). Its North American relative *Callilepis pluto* has 5-8 appendages (Platnick 1975). Species of two genera close to *Callilepis, Eilica* sp. and *Laronius erawan*, completely lost the covering setae. *Synaphosus* (Fig. 2F) has plumose setae with 6-7 pairs of appendages. The tip of the setae is slightly enlarged. It is two times longer than it is wide at its base. For species of the genus *Zelotes* the number of appendages is characteristically decreased. Thus, *Zelotes subterraneus* has 2-4 appendages on its setae, *Z. longipes* has 2-3. The plumose setae in these spiders are only on the dorsal side of the opisthosoma (Ovtsharenko 1985). The setae of *Drassyllus praeficus* do not have appendages at all. The opisthosoma of *Urozelotes rusticus* has no covering setae, only sensillae.

Spiders of the genera *Matua*, *Anzacia, Homoeothele*, *Hypodrassodes* and *Scotophaeus* have lanceolate setae (Fig. 5). The lanceolate setae are, as a rule, flat. An oval ridge ornaments them on both lateral sides. The trunk is slightly bent. The tips of the setae are serrated. This type of setae was found on the dorsal side of the opisthosoma, cephalothorax and legs; setae can be modified depending on their location on the body. The trunk of the setae of *Anzacia gemmea* is comparatively narrow and short, and also bears 4 long appendages in its proximal part, close to the base of the setae. The remainder of the trunk is broad and serrated with a sharp spike on the tip (Fig. 5C) (Ovtsharenko & Platnick 1995). Lanceolate setae on the opisthosoma of *Hypodrassodes maoricus* have one pair of proximal appendages and strongly serrated distal parts of the setae (Fig. 5D). Lanceolate setae on the cephalothorax of *Homoeothele micans* have 4 pairs of appendages in the proximal part that reach the middle of the seta; the distal part of the seta is flat and laterally serrated (Fig. 5E). The lanceolate setae on the abdomen of *Scotophaeus blackwalli* are narrow, smooth, with 3 pairs of long proximal appendages and with 4-5 slender spines at the apical part of the trunk (Fig. 6D). Modification of lanceolate setae occurs in *Matua valida,* thus setae on the abdomen are flat, wide, proximally with 3 pairs of appendages and distally on the tip with 3-4 spines on each side of the seta (Fig. 5A). The lanceolate setae on the legs of *Matua valida* are narrow, flat, with 7-8 long appendages in the proximal part of the seta and slightly serrated distal part of seta (Fig. 5B). Lanceolate setae occur sometimes together with plumose setae, mostly on the abdomen, for example in species of *Drassodes* and *Synaphosus.*

Sicate setae have a broad curved trunk and the appendages are all on one pro-curved side of the trunk, which differentiates them from the lanceolate setae (Fig. 6A-D). These setae were found mostly on the dorsal side of the abdomen and carapace (Ovtsharenko 1985). The species of the genus *Herpyllus* have sicate setae with 10 appendages of equal length set in the middle part of the setae. On its tip there are 1-2 short spines. In *Herpyllus propinquus* sicate setae bear only two rows of short (almost spine-like) 6-8 appendages on the dorsal surface of the distal part of the trunk (Fig. 6B). Beside sicate setae, spiders of this species have plumose setae on the dorsal side of their abdomen. In *Aphantaulax seminigra* and *Kishidaia conspicua* the sicate setae have up to 25-30 appendages, distributed over the whole length of the trunk (Ovtsharenko 1989). In *Cesonia bilineata* sicate setae have 4-36 appendages located on the rim of the trunk along the whole of its length. The tip of these setae bears 8-9 spines dorsally (Fig. 1A, 6A). In *Litopyllus temporarius* 15 short appendages are distributed along the total length of the trunk in two closely spaced rows, and 4 pairs of long appendages are located on the proximal part of the trunk (Fig. 6C).

Pinnate setae are characteristic of the spider genus *Gnaphosa*. They are bilateral and folded along the grooved longitudinal midline. The most peculiar characteristic of this type of setae is a marginal serration, created by short appendages, broad at the base, along the whole length of the trunk. The apex of the setae of *Gnaphosa taurica* bifurcates and has the shape of a snake's tongue (Fig. 6E). The setae of *Gnaphosa lugubris* like *G. taurica* have a longitudinal groove along the whole length of the trunk with lateral boarders bent toward the outside. These boarders have two rows of spines, broad at the base and sharp apically. The pedicel of the setae is narrow and is merged into the depression on the cuticle. Thus, the major characteristics of the setae of these spiders are the four rows of appendages, the grooved shape of the trunk, and the way it merges into the cuticle pedicel. Spiders of this genus have setae only on the

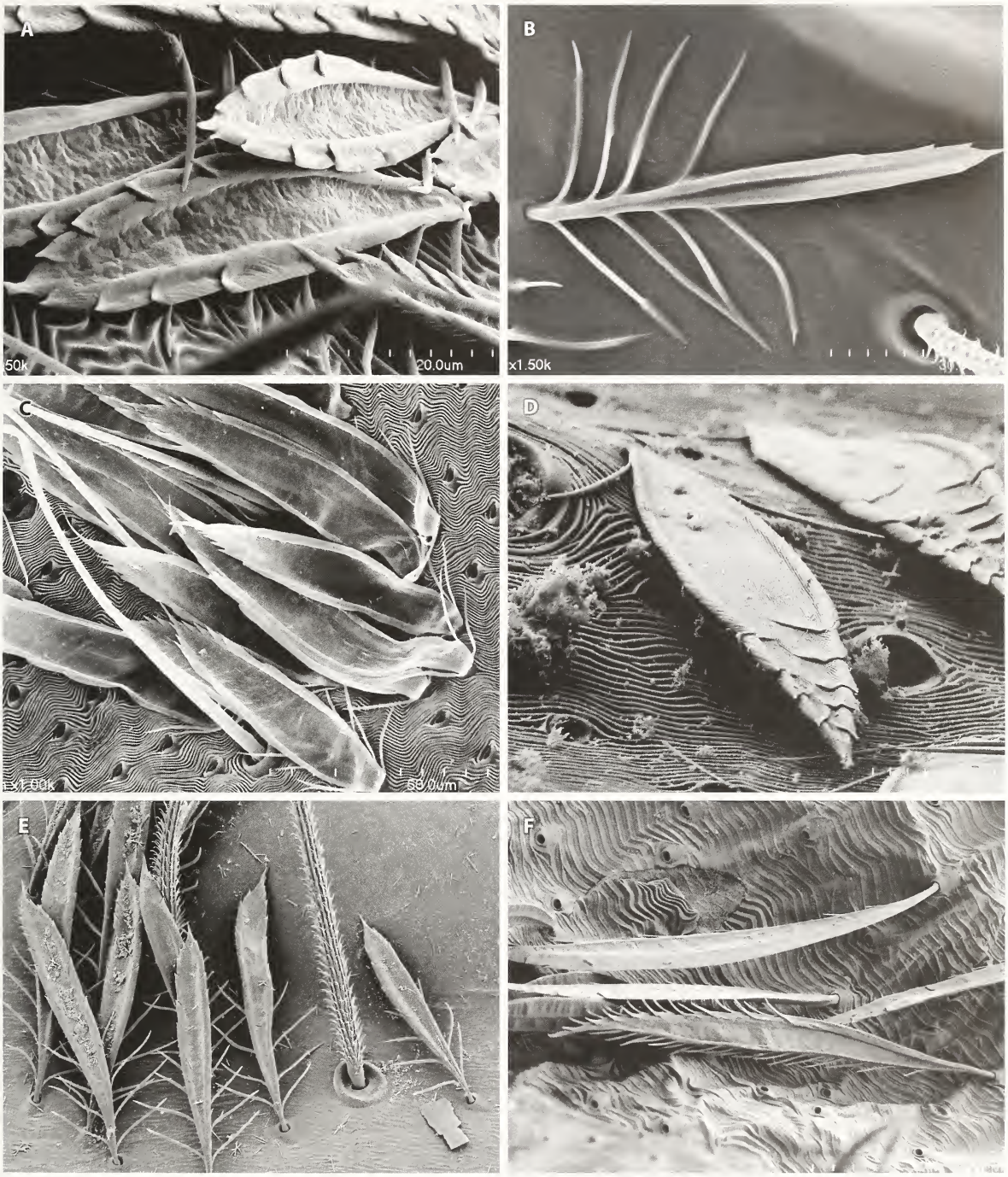

Fig. 5: Lanceolate setae on the abdomen (A, C, D), cephalothorax (E) and legs (B); sicate setae on the abdomen (F). **A, B.** *Matua valida*, **C.** *Anzacia gemmea*, **D.** *Hypodrassodes maoricus*, **E.** *Homoeothele micans*, **F.** *Cesonia bilineata*

dorsal side of the abdomen, where they create a dense coverage. Comparison of the nymphs of *Gnaphosa lugubris* with adult spiders shows that their setae are almost identical (Ovtsharenko 1985).

Arborate setae occur in the species *Fedotovia uzbekistanica* and this type of setae is the most unusual covering seta among the ground spiders. They look like branches on the trunk of a tree. The trunk of

these setae has a shaft with four longitudinal ridges. The appendages are branched from these ridges in four directions almost along the whole length of the trunk (Fig. 6F).

Discussion and conclusions

More than a third of the total known genera of gnaphosid spiders have been studied. The obtained data allow us to make some generalizations. Almost all gnaphosid spiders have covering setae on the dorsal side of their opisthosoma and additionally on the cephalothorax, legs and spinnerets. Some groups of ground spiders have very little (subfamily Zelotinae) or have no covering setae on their abdomen at all (subfamily Laroniinae). Setae demonstrate diverse appearance depending on their location on the body. Our data show the existence of stable characteristics relating to setal morphology. Depending on the shape of the setae and their accessory structures, they may be classified into six groups: squamose, plumose, lanceolate, sicate, pinnate and arborate.

Lehtinen (1967, 1975a, 1975b) was the first who pointed out the value of setal morphology for taxonomy and reconstruction of phylogenetic relationships among spiders. Galiano (1975) and Hill (1979) considered the diagnostic value of salticid scales. Ovtsharenko (1983, 1985, 1989) came to the conclusion that morphology of gnaphosids' covering setae varies among the genera and provides additional characteristics for taxonomic analysis and reconstruction of phylogenetic relationships among ground spiders. Townsend & Felgenhauer (1998a, 1998b, 1999) studied these cuticular structures and showed their usefulness for the taxonomy of oxyopid spiders. Townsend & Felgenhauer (2001), Griswold et al. (2005) and Ramírez (2014) show the importance of these characters in the phylogenetic analysis of Oxyopidae, entelegyne, and dionychan spiders. Our study supports previous observations made by Ovtsharenko (1983, 1985, 1989) that setae in the family Gnaphosidae demonstrate specific subfamilial and generic characteristics and provide valuable information for taxonomy and phylogeny of these spiders.

The role of covering setae still remains unknown. However, the type of seta attachment, the shape of the setae, and the absence of a proven association of the setae with sensory neurons (Townsend & Felgenhauer 1998a, 1998b, 1999, 2001, Foelix 2011) allow us to suggest a protective function. Hill (1979) noted that there are no verified experimental data that may suggest a specific function of the spiders' scales. At the same time, the scales' shape and design create a reflective surface that refracts light and is responsible for the colourful body pattern of jumping spiders that may be displayed during courtship (Hill 1979). Some gnaphosid spiders, such as *Micaria* and *Nauhea*, also have a metallic coloured body created by dense coverage of squamose setae.

Acknowledgements

The present study was supported in part by the Research Foundation of the City University of New York providing funds through the grant PSC-CUNY TRADA-43-582 and the American Museum of Natural History, New York. The authors are grateful to the students Amanda Tsang and Kseniia Rusinova. We are grateful to Henry Towbin and Morgan Hill from the American Museum of Natural History Microscopy and Imaging Facility for technical support with the SEM, as well as Dr. Norman I. Platnick, Curator of AMNH, for support of the study. We are very grateful to Martin Ramírez from the Museo Argentino de Ciencias Naturales, who generously provided us with his beautiful photo of the setae of *Gnaphosa taurica*. The authors are very grateful to Dr. Sandra Dickinson from the LaGuardia Community College of the City University of New York for her valuable help on the text preparation and Don N. Cameron for his help with the proper naming of setae. The authors are indebted to Dr. Martin Ramírez, Hay Wijnhoven and Theo Blick who reviewed this article and gave generously their time and expertise.

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Fig. 6: Sicate setae on the abdomen (A, B, C), lanceolate setae on the abdomen (D), pinnate setae on the abdomen (E), arborate setae on the abdomen (F). **A.** *Cesonia bilineata*, **B.** *Herpyllus propinquus*, **C.** *Litopyllus temporarius*, **D.** *Scotophaeus blackwalli*, **E.** *Gnaphosa taurica*, male (photo Martin Ramírez), **F.** *Fedotovia uzbekistanica*

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Clarification of the type locality of *Pandinus ulderigoi* with notes on the scorpions protected by CITES (Scorpiones: Scorpionidae)

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doi: 10.5431/aramit4905

Abstract. Discoveries of new species of giant scorpion (more than 14 cm in total length) are considered extremely rare. Among the largest scorpions in the world there are some species from West Africa, very popular in the pet trade and, for this reason, protected by the Washington Convention (CITES). Besides the three well-known protected species – *Pandinus imperator* (C. L. Koch, 1841), *Pandinopsis dictator* (Pocock, 1888) and *Pandinus gambiensis* Pocock, 1900 – a fourth giant species, *Pandinus ulderigoi* Rossi, 2014, was recently described from a supposedly unknown locality in the Central African Republic. Unpublished notes, just discovered, allow clarification of the exact type locality of this species. Besides newly examined material from the type locality, representative of both sexes, allows better definition of the characters of this species including its unusual trichobothrial pattern. A fifth giant species, *Pandinus roeseli* (Simon, 1872), recently revalidated from *Pandinus imperator*, is automatically included among the protected species. In light of the vulnerable status, the similar general appearance, the possibly restricted and continuous distribution with regards to the four protected species as well as the recent import suspension of *P. imperator* from Ghana, *P. ulderigoi* should be added to the *Pandinus* species protected by the Washington Convention.

Keywords: *Pandinopsis dictator*, *Pandinus gambiensis*, *Pandinus imperator*, *Pandinus roeseli*

Since the 19th century scientists have reported the existence of giant scorpions from West Africa (Koch 1841, Simon 1872, Thorell 1876, Becker 1880, Pocock 1888, 1900). Poor descriptions and loss of type material, in many cases generated confusion around these giant species resulting in a significant number of synonyms. The first officially described giant species of the genus *Pandinus* was published by Koch (1841) as *Buthus imperator* (now *Pandinus imperator*) based on a single adult specimen from an unknown locality, deposited in the Berlin Museum. Later, Simon described *Heterometrus roeseli* from Guinea (1872) and Becker (1880) described *Scorpio simoni* from an unknown locality. The latter two species were synonymized with *P. imperator* by Thorell (1893), but recently Lourenço (2014) revalidated the first one as *Pandinus roeseli*. According to Fet (2000), the holotype of *Pandinus imperator* is lost while the holotype of *Scorpio simoni* (now regarded as a synonym of *P. imperator*) could be deposited in the Bruxelles Museum, but in fact this type is not available (Baert pers. comm.). Even the holotype of *Pandinus roeseli*, apparently deposited in the Museum in Paris, is most certainly lost (Lourenço pers. comm.). In a major revision of the genus *Pandinus* – including the descriptions of several new subgenera and species – Rossi (2015) elevated the subgenera of *Pandinus* defined by Vachon (1974) to genera. Thus *Pandinopsis dictator* (Pocock, 1888) remained the only species of the monotypic genus *Pandinopsis* Vachon, 1974. Among the giant species from West Africa only the two species described by Pocock (1888, 1900) are clearly diagnosed (Vachon 1967, 1974, Lourenço & CloudsleyThompson 1996) even with a precise distribution map (Prendini 2004, Rossi 2014a).

The large species *Pandinus imperator* (C. L. Koch, 1841), *Pandinopsis dictator* Pocock, 1888 and *Pandinus gambiensis* Pocock, 1900 are now protected by the Washington Convention and were added to the CITES list, Appendix II (Lourenço & Cloudsley-Thompson 1996) because their vulnerable status is unquestionably endangered by exportation for the pet trade, especially to Europe, the USA and Japan (Prendini et al. 2003). A fourth giant species, *P. roeseli*, was already cited among the names on the CITES list, as the protected species *Heterometrus roeseli*; in fact it was expressly mentioned together with a second synonym of *Pandinus imperator*, namely *Pandinus africanus* Thorell, 1876, among the protected names (Inskipp & Gillett 2005). Since *P. roeseli* is now regarded as a valid species, it is automatically protected by CITES, taking into account the fact that it shares the same threats as *P. imperator*. An additional species from the Central African Republic,

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submitted 15.2.2015, accepted 1.6.2015, online: 10.6.2015

recently described as *Pandinus ulderigoi* Rossi, 2014, is also of very large size, with a typical adult length of between 125 and 145 mm. Unpublished notes allow clarification here of its exact type locality: Bangui. Besides newly examined material, representative of both sexes, allow a better definition of its unusual trichobothrial pattern. In consideration of its vulnerable status, similar general appearance, and possibly restricted distribution and the recent import suspension of *P. imperator*, *P. ulderigoi* should also now be added to the list of scorpions protected by the Washington Convention.

Material and methods

Descriptions and measurements (in mm) mostly follow, respectively, Hjelle (1990) and Sissom et al. (1990). The species *Pandinus ulderigoi* Rossi, 2014 is compared with the other four species protected by the Washington Convention and an updated identification key for these five species is proposed.

Abbreviations: ARPC = Andrea Rossi, Private Collection, Massa, Italy; BMNH = Natural History Museum, London, United Kingdom; HNHM = Hungarian Natural History Museum, Budapest, Hungary; MHNG = Muséum d'Histoire Naturelle de Genève, Switzerland; MSNM = Museo Civico di Storia Naturale di Milano, Italy; MZUF = Museo di Storia Naturale dell'Università degli Studi di Firenze, Sezione di Zoologia "La Specola", Italy.

Material examined

Pandinus ulderigoi Rossi, 2014

CENTRAL AFRICAN REPUBLIC: 7 km west of Bangui, X1992, leg. R. P. L. Godart, ♀ holotype, (ARPC: 0025); without locality and data, leg. local collector, ♀, (ARPC: 0026); Bangui, 2013, leg. local collector, ♀, (ARPC: 0222); Bangui, 2013, leg. local collector, ♀, (ARPC: 0223); Bangui, 2013, leg. local collector, ♀, (ARPC: 0224); Bangui, 2013, leg. local collector, ♀, (ARPC: 0225); Bangui, 2013, leg. local collector, ♀, (ARPC: 0226); Bangui, 2013, leg. local collector, ♂, (ARPC: 0227); Bangui, 2013, leg. local collector, ♀, (ARPC: 0228); Bangui, IV2006, leg. French military, ♀, (ARPC: 0245); Bangui, 1999, leg. Gianpiccolo, ♂, (ARPC: 0210); Bangui, without data, leg. local collector, ♀, (ARPC).

Pandinus imperator (C. L. Koch, 1841)

LIBERIA: without locality and data, 2 ♂♂, 2♀♀, (MHNG) ; IVORY COAST: without locality, about 1970, ♂, (ARPC: 0243).

Pandinus gambiensis Pocock, 1900 [for the year of description see the note in the references]

SENEGAL: Saint Louis, 18?? [illegible data but surely before 1893], ♀, (MZUF: 1016); without locality and data, ♂, (ARPC: 0264); GUINEABISSAU: Lugadjole, Boè oriental, IX1977, dono Dr. Lacchini, ♂, (MSNM).

Pandinus roeseli (Simon, 1872)

GUINEA: Fouta Djallon, leg. local collector, 1994, ♀, (ARPC: 0244).

Pandinopsis dictator (Pocock, 1888)

CAMEROON: without locality, 1931, leg. Dr. R. Tusek, ♂, (HNHM: 1444); Yaoundé, about 1985, leg. local collector, ♂, (ARPC: 0254); "WESTAFRICA": without locality, purchased Stevens, ♀ syntype, (BMNH: 65.33).

Results and discussion

As explained by Rossi (2014a), *P. ulderigoi* was described from the Central African Republic, where scorpions of the genus *Pandinus* had never before been recorded, except for a single specimen of an undetermined species cited by Prendini et al. (2003). Unfortunately, when it was described, the label of the female holotype did not indicate a precise locality and thus the type locality remained unknown. A second female specimen from the Central African Republic, cited in the original description, but not included in the type series, again has a label without a precise locality. The original attached data for the holotype were only: "Rep. Centrafricana" (equivalent to "Repubblica Centrafricana", which means Central African Republic, in Italian), "X-1992" (evidently equivalent to October 1992), "R. P. G." (equivalent to "Révérend Père Godart"; in fact previously I was not able to interpret this acronym). Only recently was it possible to contact the person who gave me, in the year 1996, the specimen which eventually became the holotype of *Pandinus ulderigoi*. Thanks to the valuable help of Mr. Giuliano Russo, who kept the specimen for several years, I am now able to clarify the precise type locality of *Pandinus ulderigoi*. The specimen was collected, together with a large number of insects (mainly Lepidoptera), by Louis Godart, a French Catholic missionary, who spent 43 years of his life in the Central African Republic. The exact locality where the specimens were collected is located about 7 km west of Bangui, the capital city of the Central African Republic, in a forest near Bimbo. Thus, according to the ICZN article 76.1: "The type locality

Fig. 1: Map of Africa with the known distribution of the four species protected by CITES and *Pandinus ulderigoi*. Yellow square = *Pandinus gambiensis* Pocock, 1900; inverted purple triangle = *Pandinus roeseli* (Simon, 1872); green circle = *Pandinus imperator* (C. L. Koch, 1841); blue triangle = *Pandinopsis dictator* (Pocock, 1888); red rhombus = *Pandinus ulderigoi* Rossi, 2014. Data from Prendini (2004), Rossi (2014a), Lourenço (2014) and the present contribution.

of a nominal species-group taxon is the geographical [...] place of capture, collection or observation of the name-bearing type [...]" and according to all its Recommendations such as 76A.1: "In ascertaining or clarifying a type locality [...] an author should take into account: data accompanying the original material; collector's notes, itineraries, or personal communications; the original description of the taxon; and as a last resort, and without prejudice to other clarification, localities within the known range of the taxon or from which specimens referred to the taxon had been taken".and 76A.2: "A statement of a type locality that is found to be erroneous should be corrected", the type locality of *Pandinus ulderigoi* Rossi, 2014

is hereby clarified and restricted to Bangui, Central African Republic. Besides newly examined material, a representative of both sexes was collected in the region of Bangui, the type locality (Fig. 1). The locality is near the course of the Ubangi River which is the largest right-bank tributary of the Congo River and represents the political border between the Central African Republic and the Democratic Republic of the Congo: it could be a natural barrier for scorpion dispersion and thus this species may not be present in the Democratic Republic of the Congo. The distribution of *Pandinus* seems to be divided in two large areas of distribution, one in West Africa, and another in East Africa. However two recently described species, *P. ulderigoi* and *P. camerounensis* Lourenço, 2014, brought new evidence to the suggestion that species of this genus are also present in Central Africa (Rossi 2014a, Lourenço 2014). *Pandinus camerounensis* is recorded from a zone of transition between the Sahel and the savannahs in the northern Cameroon while *P. ulderigoi* in an area of transition between moist savannah and rain forest on the borders between the Central African Republic and the Democratic Republic of the Congo (Fig. 2). As reported by Lourenço & CloudsleyThompson (1999) and more recently by Lourenço (2014), scorpions of the genus *Pandinus* occupy well defined ecological zones in West Africa represented by dry savannah or moist rain forests. Some species of *Pandinurus* from EastAfrica and Yemen, previously included in the genus *Pandinus*, can also occupy semidesert habitat (Rossi 2014a, 2014b, 2014c, 2015).

Addition to the description of *Pandinus ulderigoi* Rossi, 2014, based on topotypes

Short diagnosis: Total length 125–145 mm. Colour of adults uniformly reddish brown to greenish black: legs coloured like body. Number of pectinal teeth 14–16 in males, 13–16 in females. Chela with 3 internal and 10–11 ventral trichobothria. The 3 internal trichobothria have the most basal (ib) separated from the other two by twice (or even more) the distance which separate the first two (it, ist). Dorsal surface of chela manus with many granules, usually not pointed, and dense setation. Spiniform formula of tarsomere II = 456/3: 56/3: 56/3: 56/3. Tarsomere II with 2 spines on the inclined anteroventral surface. Length to height ratio of 4th metasomal segment always lower than 2. Width to height ratio of 5th metasomal segment lower than 1.

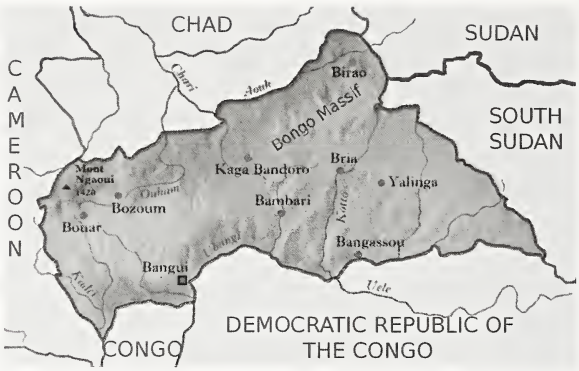

Fig. 2: Physical map of the Central African Republic with the type locality of *Pandinus ulderigoi* Rossi, 2014 indicated by a red square

Identification key for the species of scorpions in CITES list and *Pandinus ulderigoi* Rossi, 2014

1. Chela with 2 internal and 4 ventral trichobothria (Fig. 3) ..... *Pandinopsis dictator* (Pocock, 1888) (Fig. 4)
– Chela with 3 internal and 9–14 ventral trichobothria (Fig. 5) 2
2. Internal trichobothria dispersed in a straight line and of equal distance apart (Fig. 5, 7) 3
– Internal trichobothria have the most basal (ib) separated from the other two by twice (or even more) the distance which separate the first two (it, ist) (Fig. 9, 11) 4
3. Distal lamina of hemispermatophore weakly curved with basal portion larger than the distal one; presence of a tubercular structure in the apex ... .. *Pandinus imperator* (C. L. Koch, 1841) (Fig. 6)
– Distal lamina of hemispermatophore not curved; completely large over its entire surface; absence of a tubercular structure in the apex .... *Pandinus roeseli* (Simon, 1872) (Fig. 8)
4. Tarsomere II with three spines on the inclined anteroventral surface; dorsal surface of chela and metasomal carinae strongly tuberculated with spinoid granules .... *Pandinus gambiensis* Pocock, 1900 (Fig. 10)
– Tarsomere II with two spines on the inclined anteroventral surface; dorsal surface of chela and metasomal carinae weakly tuberculated .... *Pandinus ulderigoi* Rossi, 2014 (Fig. 12)

(for the illustrations of the hemispermatophores, see Lourenço 2014)

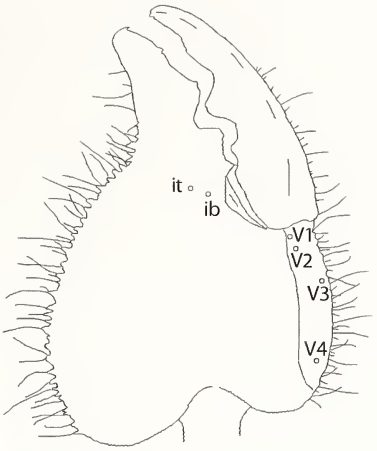

Fig. 3: Chela of *Pandinopsis dictator* (Pocock, 1888) showing internal and ventral trichobothria

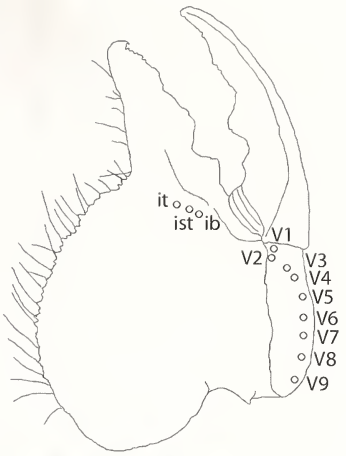

Fig. 5: Chela of *Pandinus imperator* (C. L. Koch, 1841) showing internal and ventral trichobothria

Fig. 4: *Pandinopsis dictator* (Pocock, 1888) ♂ from Cameroon, 115 mm (HNHM)

Fig. 6: *Pandinus imperator* (C. L. Koch, 1841) ♂ from Liberia, 180 mm (MHNG)

Conclusions

P. ulderigoi can be considered as being among the largest scorpion species in the world and it could be subject to massive exportation from the Central African Republic to avoid CITES regulation, especially given that since 2012 the European Union have suspended imports of *P. imperator* from Ghana, which was the main supplier. The *Pandinus* species are not easily identified by customs officers and their continuous geographical distribution does not help to distinguish them by their origins alone. *P. ulderigoi* can be distinguished from *P. imperator* and *P. roeseli* mainly by the different position of the internal trichobothria of the pedipalp chela. *P. ulderigoi* can be distinguished from *P. gambiensis* by the different number of spines on the inclined anteroventral surface of tarsomere II and by the spinoid granules on the dorsal surface of the pedipalp chela and on the metasomal carinae.

Fig. 7: Chela of *Pandinus roeseli* (Simon, 1872) showing internal trichobothria

Fig. 8: *Pandinus roeseli* (Simon, 1872) ♀ from Guinea, 170 mm (ARPC)

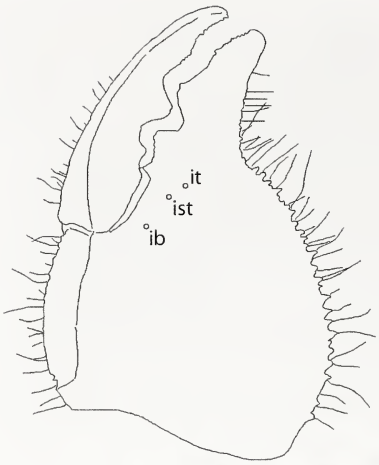

Fig. 9: Chela of *Pandinus gambiensis* Pocock, 1900 showing internal trichobothria

Fig. 10: *Pandinus gambiensis* Pocock, 1900 ♀ from Senegal, 165 mm (MZUF)

Finally *Pandinus ulderigoi* can be easily distinguished from *Pandinopsis dictator* by a different number of internal and ventral trichobothria.

In consideration of the vulnerable status, the similar general appearance, the possibly restricted and continuous distribution with regards to the four protected species, as well as the recent import suspension of *P. imperator* from Ghana, I strongly urge that *P. ulderigoi* be added to the *Pandinus* species protected by the Washington Convention.

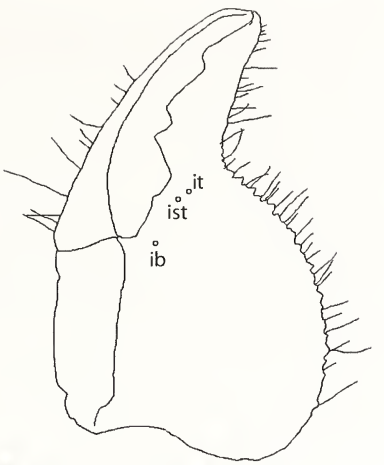

Fig. 11: Chela of *Pandinus ulderigoi* Rossi, 2014 ♀ holotype, showing internal trichobothria

Fig. 12: *Pandinus ulderigoi* Rossi, 2014 ♀ from Central African Republic, 145 mm (ARPC)

Acknowledgements

I am very grateful to Dr Janet Beccaloni (BMNH), Dr László Dányi (HNHM), Dr Peter Schwendinger (MHNG), Dr Monica Leonardi (MSNM) and Dr Luca Bartolozzi (MZUF) for allowing me to study the material in their care, and to Dr Léon Baert and to Prof. Wilson R. Lourenço for information about historical type material. I also thank Gérard Dupré for his kind help in many ways, Alessandro R. Theunissen for a preliminary revision of the manuscript and Dr. Maria Chiara Merendino for legal advice. Besides this work was possible thanks to the valuable help of Giuliano Russo, who gave me precious information on the holotype of *Pandinus ulderigoi*, and Dr Alberto Ballerio (ICZN Commissioner), who gave me important support in understanding ICZN Articles and Recommendations as well as CITES regulations.

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Stenochrus portoricensis, Zomus bagnallii and a new genus of schizomids (Schizomida: Hubbardiidae) from a greenhouse in Frankfurt am Main, Germany

Luis F. de Armas & Stefan Rehfeldt

doi: 10.5431/aramit4906

Abstract. A new genus of hubbardiid schizomid, *Bucinozomus* **gen. nov.** with the single species *B. hortuspalmarum* **spec. nov.**, is described on basis to two male specimens found in the "Palmengarten" greenhouse in Frankfurt am Main, Germany. It clearly differs from other known genera by having a long and conical abdominal segment IX, as well as the following combination of characters: anterodorsal margin of femur IV produced at less than a 90° angle, metapeltidium divided, and pedipalps with prominent spinose setae. It differs from *Trithyreus* Kraepelin, 1899 by having the pedipalp trochanter with a mesal spur, leg femur IV not slender and a pedipalp tarsus with a shorter claw (half of tarsus length). Living sympatric with this new taxon were female specimens of *Stenochrus portoricensis* Chamberlin, 1922 and *Zomus bagnallii* (Jackson, 1908).

Keywords: Europe, Hubbardiinae, short-tailed whipscorpions, taxonomy

Zusammenfassung. *Stenochrus portoricensis, Zomus bagnallii* und eine neue Zwerggeißelskorpion-Gattung (Schizomida: Hubbardiidae) aus einem Gewächshaus in Frankfurt am Main, Deutschland. Die neue Zwerggeißelskorpion-Gattung *Bucinozomus* **gen. nov.** (Schizomida: Hubbardiidae) mit der bisher einzigen bekannten Art *B. hortuspalmarum* **spec. nov.** wurde erstmalig anhand von zwei männlichen Individuen, welche in den Gewächshäusern des Palmengartens in Frankfurt am Main (Deutschland) gefunden wurden, beschrieben. Sie unterscheidet sich deutlich von allen anderen bisher bekannten Gattungen durch den Besitz eines langen, kegelförmigen Abdominalsegments IX, so wie durch eine Kombination folgender Merkmale: Der anterodorsale Rand des Femurs IV bildet einen Winkel unter 90° aus, das Metapeltidium ist geteilt und die Pedipalpen weisen auffällig stachelige Setae auf. Von der Gattung *Trithyreus* Kraepelin, 1899 lässt sich die neue Gattung anhand eines mesalen Sporns auf den Pedipalpen-Trochantern, einem insgesamt weniger schlanken Femur IV und kürzeren Klauen an den Pedipalpentarsen (Hälfte der Tarsuslänge) unterscheiden. Am Fundort kommt *B. hortuspalmarum* **spec. nov.** sympatrisch mit Weibchen von *Stenochrus portoricensis* Chamberlin, 1922 und *Zomus bagnallii* (Jackson, 1908) vor.

Schizomids are an understudied order of arachnids mainly distributed in tropical and subtropical areas, although three species have been accidentally introduced into Europe: *Stenochrus portoricensis* Chamberlin, 1922, *Schizomus crassicaudatus* (O. P.-Cambridge, 1872) and *Zomus bagnallii* (Jackson, 1908) (Reddell & Cokendolpher 1995, Harvey 2003, Korenko et al. 2009, Nedvěd et al. 2011, Christophoryová et al. 2013, Zawierucha et al., 2013) (Tab. 1). From German greenhouses, Cokendolpher et al. (2006) and Blick et al. (2006) recorded further undetermined schizomids from Frankfurt am Main.

As a result of several samplings during 2012-2014 in the wet tropical section of a greenhouse in Frankfurt am Main, the second author (SR) collected schizomid specimens belonging to three species, one of which represents a new genus and species, which are herein described.

Material and methods

This study was based on 12 specimens (two males; ten females) from a greenhouse in Frankfurt am

Tab.1: Schizomid species introduced into Europe

species	country and reference
Bucinozomus hortuspalmarum	Germany (this paper)
Schizomus crassicaudatus	France (Pickard-Cambridge 1872)
Stenochrus portoricensis	Czech Republic (Korenko et al. 2009), Germany (this paper), Great Britain (Reddell & Cokendolpher 1995), Poland (Zawierucha et al. 2013), Slovakia (Christophoryová et al. 2013), Spain (Canary Islands: Martín & Oromi 1984, Sevilla: Barranco et al. 2014)
Zomus bagnallii	Germany (this paper), Great Britain (Jackson 1908)

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submitted: 22.8.2014, accepted 12.1.2015, online 10.6.2015

Main, Germany. The specimens are deposited in the following institutions:

IES Instituto de Ecología y Sistemática, La Habana, Cuba.

MfN: Museum für Naturkunde, Leibniz Institute for Evolution and Biodiversity Science, Berlin, Germany.

SMF: Senckenberg Museum, Frankfurt am Main, Germany.

Nomenclature follows Reddell & Cokendolpher (1995). Notation for chaetotaxy of tergites I–VIII is that of Harvey (1992). For flagellar chaetotaxy we follow Harvey (1992), as modified by Reddell & Cokendolpher (1992) and Moreno-Gonzalez et al. (2014). The setal group numbering for the chelicerae follows Lawrence (1969); with notation of the formula as suggested by Moreno-Gonzalez & Villarreal (2012). Measurements are given in millimeters; total length excludes the flagellum; pedipalps and legs exclude the coxae.

Taxonomy

Family Hubbardiidae Cook, 1899

Subfamily Hubbardiinae Cook, 1899

Genus *Bucinozomus* **gen. nov.**

Type species: *Bucinozomus hortuspalmarum* **spec. nov.**

Diagnosis: The elongate and cylindrical abdominal segment IX of the adult male of *B. hortuspalmarum* **spec. nov.** (Figs 1-5), is unlike that of any other schizomid genus. Also, the following combination of characters differentiate this taxon from other Hubbardiidae: anterior process of propeltidium with 2+1 setal arrangement; pedipalps presumably sexually dimorphic; male pedipalps armed with spinose setae (Figs 9-11); anterodorsal margin of femur IV produced at less than a 90° angle (Fig. 12); metapeltidium divided (Fig. 6); and male abdominal segments IX–XII attenuated (Figs 1-5).

The only hubbardiid genera having the anterodorsal margin of femur IV produced at less than a 90° angle are *Clavizomus* Reddell & Cokendolpher, 1995 (Singapore, West Malaysia and Java), *Heterocubazomus* Teruel, 2007 (Cuba, West Indies), *Reddellzomus* Armas, 2002 (Cuba), *Tayos* Reddell & Cokendolpher, 1995 (Ecuador, South America), *Thrithyreus* Kraepelin, 1899 (Myanmar), and an undescribed genus from Guerrero State, Mexico, mentioned by Armas & Palacios-Vargas (2006). *Bucinozomus* closely resembles *Trithyreus* and *Clavizomus* by having spinose setae on the pedipalps, but it differs from the former by having a trochanter with a mesal spur, leg femur IV not slender, and a pedipalp tarsus with shorter spurs and claw (half of tarsus length). On the other hand, the female of *T. grassii* (Thorell, 1889) lacks eye spots. *Clavizomus* is characterized by having clavate setae on the body and legs; a mesal spur on the pedipalp trochanter is also lacking. The New World genera *Heterocubazomus, Reddellzomus* and *Tayos* clearly differ from *Bucinozomus* by having pedipalps without spinose setae, an anterior process of the propeltidium with 1+1 setae, male pedipalps not sexually dimorphic (*Tayos*, *Reddellzomus*), and the metapeltidium entire (*Reddellzomus*).

Description: Anterior process of propeltidium with two setae followed by another one (2+1); corneate eyes absent; metapeltidium clearly divided (Fig. 6). Body without clavate setae. Pedipalps sexually dimorphic. Male pedipalps armed with strong mesal spur on trochanter and short, strong spiniform setae on ventroanterior surface of the femur (Figs 9-10). Movable cheliceral finger without accessory tooth (Fig. 13), with a guard tooth at end of serrula. Anterodorsal margin of femur IV produced at less than a 90° angle (Fig. 12). Male abdominal segments IX elongate and cylindrical (Figs 1-5). Abdominal tergite II with two posterior setae. Abdominal segment XII of males without dorsal process (Fig. 7).

Etymology: The generic name is derived from the Latin noun bucina (trumpet), relating to the very attenuate last abdominal segments of the male, and the name *Zomus* Reddell & Cokendolpher, 1995. It is masculine in gender.

Remarks: Although this new genus is known only from male specimens, the diagnostic characters are sufficient for its correct identification.

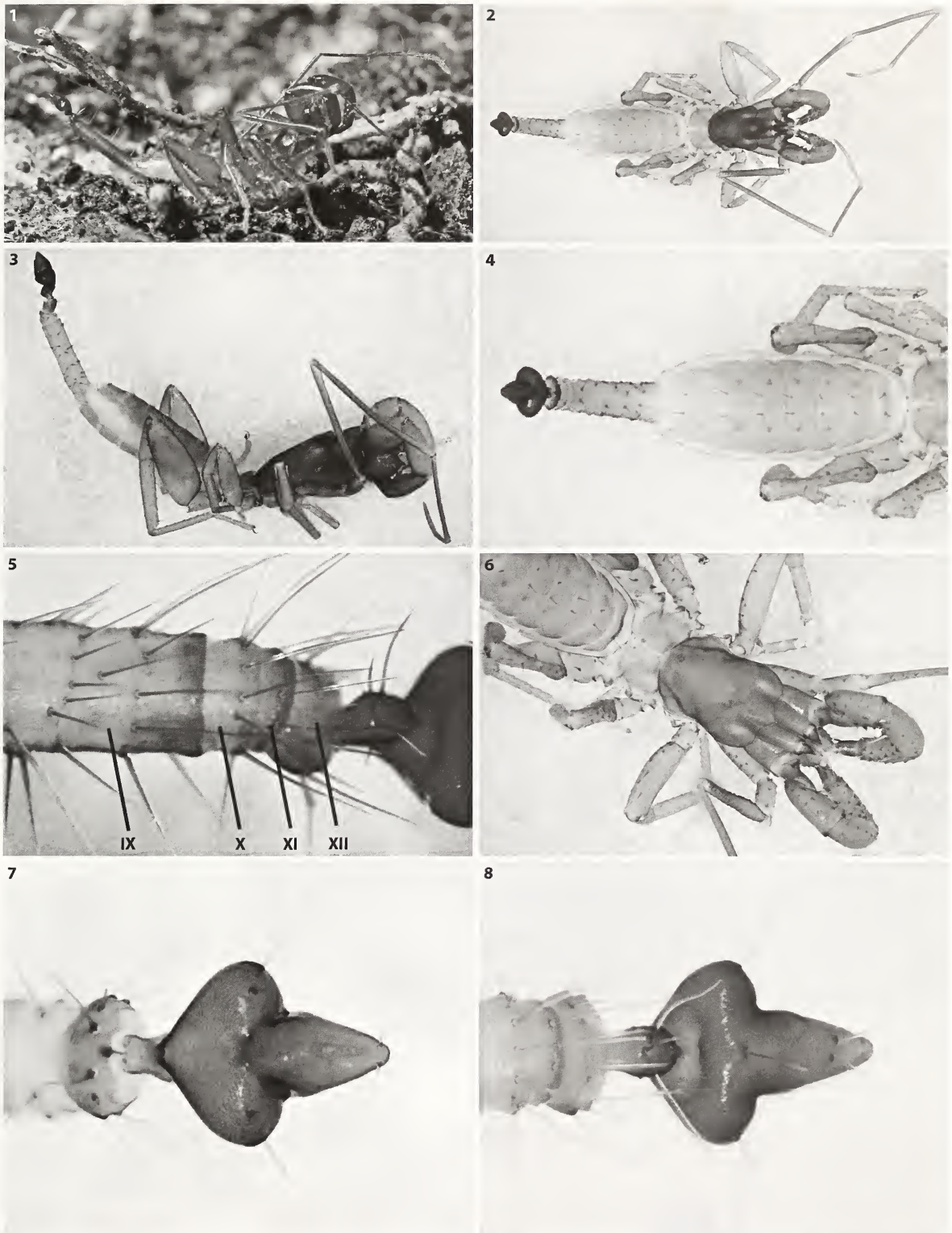
Bucinozomus hortuspalmarum **spec. nov.**

Figs 1–15, Tabs 1–2

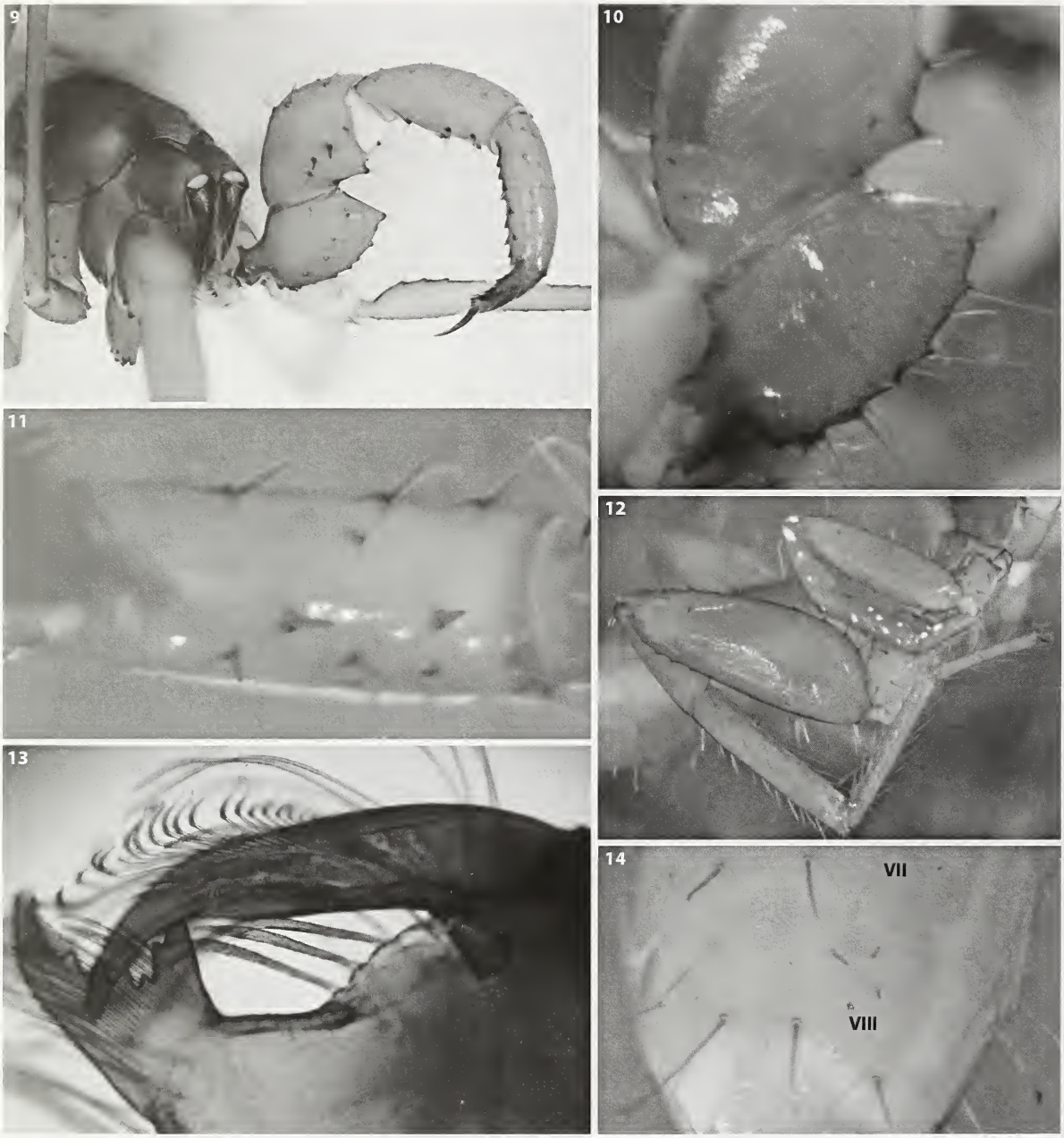
Type data: Holotype ♂ (SMF), GERMANY: Frankfurt am Main: Palmengarten; Tropicarium (N 50°07'27.28" – E08°39'23.89", approximately 112 m a.s.l.), 22 February, 2012; leg. Stefan Rehfeldt (in greenhouse; section: coastal and mangrove forests; under a stone; near an allotment of rice). Paratype: ♂ (MfN), 26 March, 2013; other data same as the holotype.

Distribution: Only known from the type locality (Fig. 15).

Diagnosis: Propeltidium with three pairs of dorsal setae. Male flagellum with the bulb fleur-de-luce-



Figs 1-8: *Bucinozomus hortuspalmarum*. Male holotype. 1, alive in the Frankfurt greenhouse. 2-3, habitus dorsal (2) and lateral (3). 4, opisthosoma, dorsal. 5, Abdominal segments IX–XII, ventral aspect. 6, prosoma and first tergites, dorsal. 7-8, last abdominal segments and flagellum, dorsal (7) and ventral (8)



Figs 9-14. *Bucinozomus hortuspalmarum*. Male holotype. 9-11, pedipalp: mesal view (9), trochanter and femur, external aspect (10), patella, ventral aspect (11). 12, Legs III-IV. 13, chelicera, fixed and movable finger. 14, tergites VII-VIII.

shaped in dorsal and ventral aspect, without dorsomedian prominences (Fig. 8).

Male: Yellowish-brown, with propeltidium, chelicerae, pedipalp coxae and flagellum darker. Propeltidium with three pairs of dorsal setae; ocular spots irregular in form, sub ovate. Metapeltidium clearly divided (Fig. 6). Anterior sternum with 11+2 setae. Cheliceral fixed finger with four accessory teeth (Fig. 13); serrula on the movable finger with 25 hyaline teeth. Chaetotaxy: setal group formula: 3-2-2-3-19-1; G1 (setae group 1) with three spatulate setae, having each the basal part smooth, and the rest with minute spiniform spicules. Pedipalps (Figs 9-11): trochanter apically pronounced, sharp-pointed, with

Figs 15-17. General view of the Frankfurt greenhouses (15). Living females of *Stenochrus portoricensis* (16) and *Zomus bagnallii* (17), both from the Frankfurt greenhouses

a mesal spur; femur 1.7 times longer than high, with two stout ventroanterior setae, the basal one on a large tubercle; patella 1.1 times longer than femur and 3.0 times longer than high; claw 0.6 times as long as the dorsal length of the tarsus. Chaetotaxy of tergites I-VIII: 2+4 (microsetae diagonal): 2+4 (microsetae in column):2:2:2:2:2:5+4 (Figs 4, 6, 14). Segment IX with more than 10 dorsal setae (Figs 3-5); X and XI very short; X with a pair of large dorsolateral setae and six pairs of ventral setae; XI with six pairs of ventral setae; XII without dorsal median eminence, with four dorsal setae, a pair of lateral setae and six ventral setae. Flagellum resembles, at grosso modo, an *Iris* flower (Figs 7-8); bulb 1.3 times longer than wide, without dorsomedian eminences; chaetotaxy: 15 setae (7 dorsal, 8 ventral), dm1 on the bulb base, dl1 basal to vm1 level, dl2 almost at the same level than vl1, vm1 basal to vm2, vm5 in middle of the bulb, dl3 near to the apex, clearly shorter than vl2; laterally and basal to dl2 there are two pairs of microsetae; dm5 and vm4 are lacking. Measurements (see Tab. 2).

Female: Unknown.

Etymology: The specific name is derived from the Latin words hortus (garden) and palmarum (genitive plural of palm), because the schizomid specimens were found in a greenhouse of the Palm Garden in Frankfurt.

Natural history: The only available specimens (two males) were found under stones in the palm garden (Palmengarten) of the Frankfurt greenhouse, sympatric with *S. portoricensis*.

Tab. 2: Measurements (mm) of *Bucinozomus hortuspalmarum*. H, height; L, length; W, width.

characters	♂ holotype
Total body L	6.20
Propeltidium, L/W	1.55/0.98
Flagellum, L/W/H	0.83/0.52/0.33
Pedipalp, L	4.04
Trochanter, L/H	0.88/0.41
Femur, L/H	0.93/0.52
Patella, L/H	1.01/0.33
Tibia, L/H	0.83/0.28
Tarsus, L	0.39
Claw, L	0.23
Leg I, L	8.90
Femur, L	2.10
Leg IV, L	5.90
Femur, L/H	1.69/0.60

Comments: On May 2014, SR again visited the greenhouse in Frankfurt, but unfortunately only one specimen of *Z. bagnallii* was found, no other schizomids. The plants near the location were watered very intensively and this could have been the reason for the schizomids scarcity during this visit.

Stenochrus portoricensis Chamberlin, 1922
Fig. 16, Tab. 1
First record for GERMANY: Frankfurt am Main: Palmengarten; Tropicarium (N50°7'27.28 – E8°39'23.89, approximately 112 m a.s.l.): 5 ♀♀ (IES), 22 February, 2012; leg. Stefan Rehfeldt (greenhouse; section: coastal and mangrove forests; under a stone; near an allotment of rice).

Comments: Korenko et al. (2009) wrote that "*Stenochrus portoricensis* [...] has been accidentally introduced into many countries [...] and even in Europe: [...] Great Britain and Germany (Blick 2006, Cokendolpher et al. 2006)." On the other hand, according to Nedvěd et al. (2011), "Blick (2010) recorded *S. portoricensis* from Germany", but they wrongly cited this 2006-online-source. Also, Theo Blick (e-mail to SR on August 2014) wrote that the records of *S. portoricensis* in Germany have not been published with this species name so far.

Zomus bagnallii (Jackson, 1908)
Fig. 17, Tab. 1
First record for GERMANY: Frankfurt am Main: Palmengarten; Tropicarium (N 50°7'27.28 – E8°39'23.89, approximately 112 m a.s.l.): 2♀♀ (SMF), 22 February, 2012; 2♀♀ (SMF), 29 March, 2013; 1♀ (SMF), 17 May, 2014; leg. Stefan Rehfeldt (in greenhouse; sections: coastal and mangrove forests; monsoon and trade wind forests; and the bromeliad house; under stones and under flower pots).

Discussion

Three schizomid species are now known to occur in German greenhouses. There is evidence that at least one of them reproduces in this habitat (Blick et al. 2006). *Stenochrus portoricensis* and *Z. bagnallii* are relatively widespread in the Frankfurt am Main greenhouse, where they became established more than ten years ago (Blick et al. 2006, Cokendolpher et al. 2006). But this is not the case for *B. hortuspalmarum*, only known from two male specimens collected in the Palmengarten.

Stenochrus portoricensis naturally occurs in several countries of the New World (Reddell & Cokendolpher 1995), from which it has been introduced into the Canary Islands and several European countries (Tab. 1). *Zomus bagnallii* was imported to France from Sri Lanka. But the bizarre *B. hortuspalmarum* was inadvertently introduced into the German greenhouse from an unknown country, although some of its morphological characters clearly resemble those of certain south-eastern Asian genera (such as *Clavizomus* and *Trithyreus*), perhaps the area in which it naturally occurs.

Acknowledgements
We are much indebted to Mark S. Harvey (Western Australian Museum) for identification of *Zomus bagnallii* specimens. Oscar F. Francke and David Ortiz Martínez (Instituto de Biología, UNAM, Mexico, D. F.) kindly mediated in the transport of specimens from Germany to Cuba. Theo Blick (Frankfurt) generously supplied some literature and information on the alleged records of *S. portoricensis* from Germany. James C. Cokendolpher (Museum of Texas Tech University, USA) and an anonymous referee contributed towards improving the final version of this paper.

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Ein Beitrag zur Springspinnenfauna der Balearen mit dem Erstnachweis von *Heliophanus stylifer* für Europa (Araneae, Salticidae)

Michael Schäfer

doi: 10.5431/aramit4907

Abstract. Contribution to the jumping spider fauna of the Balearic Islands with the first record of *Heliophanus stylifer* in Europe (Araneae, Salticidae). A female of the jumping spider *Heliophanus stylifer* Simon, 1878 was found in the s'Albufera natural park on the Balearic Island of Mallorca (Spain). This species is new to Europe. Seven additional jumping spider species were recorded, including the first records of *Heliophanus apiatus, Icius hamatus* and *Menemerus taeniatus* for the Balearic Islands.

Key words: distribution, Europe, new faunistic record, spider

Zusammenfassung. Ein Weibchen der Springspinne *Heliophanus stylifer* Simon, 1878 wurde im Naturpark s'Albufera auf der Balearen-Insel Mallorca (Spanien) gefunden. Die Spezies ist neu für Europa. Außerdem wurden weitere sieben Springspinnenarten nachgewiesen, darunter mit *Heliophanus apiatus, Icius hamatus* und *Menemerus taeniatus* drei Arten erstmalig für die Balearen.

Während eines Aufenthaltes an der Nordküste der Baleareninsel Mallorca in der Zeit vom 22.03. bis 01.04.2014 wurden acht Springspinnenarten aus sechs Gattungen nachgewiesen. Die insgesamt 34 Einzelindividuen wurden ausschließlich in und um Alcudia sowie im Naturpark s'Albufera gesammelt. Vier Arten konnten erstmals für die Balearen nachgewiesen werden. Unter ihnen mit *Heliophanus stylifer* Simon, 1878 eine Art, die bisher noch nicht aus Europa bekannt war. Die drei anderen für die Balearen neuen Arten sind *Heliophanus apiatus* Simon, 1868, *Icius hamatus* (C. L. Koch, 1846) und *Menemerus taeniatus* (L. Koch, 1867). Das Material wurde vom Autor gesammelt und bestimmt. Die Koordinaten der Fundorte sind im geodätischen Datum WGS84 angegeben.

Abb. 1: *Aelurillus balearus,* Männchen, Dorsalansicht
Fig. 1: *Aelurillus balearus,* male, habitus dorsal

Aelurillus balearus Azarkina, 2006 (Abb. 1-4)

Mallorca: Naturpark s'Albufera, 39.782517°N 3.1347°E, 1 m ü. NN. Graudüne. 31.03.2014: 3♂, 1♀; Naturpark s'Albufera, 39.784583°N 3.130767°E, 3 m ü. NN. offene Sandstellen im Küstendünenwald. 28.03.2014: 3♂. Bestimmung: Azarkina (2006). Verbreitung: Kanarische Inseln, Balearen (World Spider Catalog 2015).

Da die Art erst im Jahr 2006 beschrieben wurde und bisher keinerlei Fotos zum Habitus veröffent-

Abb. 2: *Aelurillus balearus,* Männchen, Frontalansicht
Fig. 2: *Aelurillus balearus,* male, habitus frontal

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eingereicht: 5.1.2015, angenommen: 2.2.2015, online: 10.6.2015

Abb. 3: *Aelurillus balearus,* Weibchen, Dorsalansicht
Fig. 3: *Aelurillus balearus,* female, habitus dorsal

Abb. 4: *Aelurillus balearus,* Weibchen, Frontalansicht
Fig. 4: *Aelurillus balearus,* female, habitus frontal

licht wurden, folgen an dieser Stelle Dorsal- (Abb. 1 und Abb. 3) und Frontalfotos (Abb. 2 und Abb. 4) von beiden Geschlechtern.

***Aelurillus luctuosus* (Lucas, 1846) (Abb. 5-8)**

Mallorca: Naturpark s'Albufera, 39.784583°N 3.130767°E, 3 m ü. NN. offene Sandstellen im Küstendünenwald. 28.03.2014: 4♂, 8♀, vid. G. Azarkina. Bestimmung: Azarkina & Logunov (2006), Metzner (1999). Verbreitung: mediterran bis Turkmenistan (World Spider Catalog 2015).

Interessanterweise scheinen in der Population Tiere zwei verschiedener Typen zu existieren, die sich zumindest bei den Weibchen, sowohl genital als auch im Aussehen voneinander unterscheiden. Während Typ A von der Grundfarbe weißlich-rosa gefärbt ist und eine kontrastreiche Musterung aufweist (Abb. 5), sind die Weibchen vom Typ B hell- bis dunkelgrau mit weit weniger kontrastreicher Zeichnung gefärbt (Abb. 7). Korrelierend zum unterschiedlichen Aussehen unterscheiden sich auch die Strukturen der Epigynen beider Typen (Abb. 6 und Abb. 8). Die Unterschiede liegen allerdings innerhalb der Variationsbreite der Art (Azarkina & Logunov 2006),

Abb. 5: *Aelurillus luctuosus,* Typ A, Weibchen, Dorsalansicht
Fig. 5: *Aelurillus luctuosus,* Type A, female, habitus dorsal

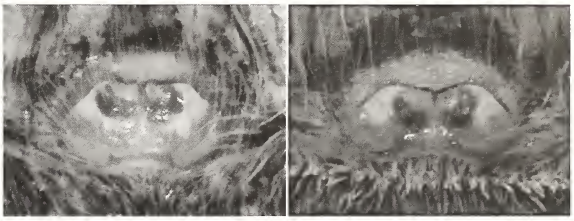

Abb. 6: *Aelurillus luctuosus,* Typ A, Weibchen, Epigyne
Fig. 6: *Aelurillus luctuosus,* Type A, female, epigyne

Abb. 7: *Aelurillus luctuosus,* Typ B, Weibchen, Dorsalansicht
Fig. 7: *Aelurillus luctuosus,* Type B, female, habitus dorsal

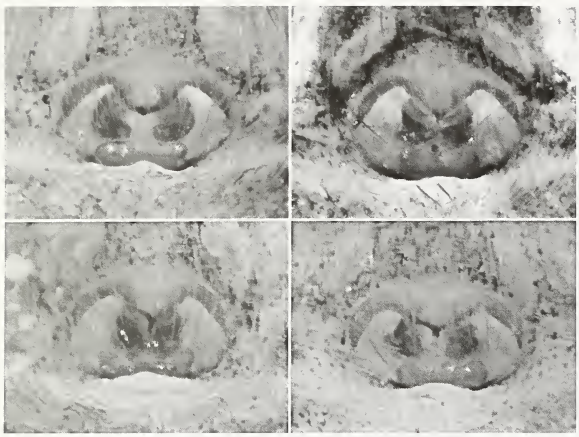

Abb. 8: *Aelurillus luctuosus*, Typ B, Weibchen, Epigyne
Fig. 8: *Aelurillus luctuosus*, Typ B, female, epigyne

so dass hier nicht von zwei verschiedenen Arten ausgegangen werden kann (schriftl. Mitt. G. Azarkina).

***Chalcoscirtus infimus* (Simon, 1868)**
Mallorca: Naturpark s'Albufera, 39.77775°N 3.127°E, 1 m ü. NN. Wegrand unter Stein. 29.03.2014: 1♂. Bestimmung: Metzner (1999). Verbreitung: Süd- und Mitteleuropa bis Zentralasien (World Spider Catalog 2015).

***Heliophanus apiatus* Simon, 1868**
Mallorca: Alcudia, 39.79225°N 3.1267°E, 1 m ü. NN. auf Holzgeländer an Strandaufgang. 23.03.2014: 1♂; 39.789967°N 3.12475°E, 7 m ü. NN. auf Gehweg zwischen Pflastersteinen. 24.03.2014: 1♂. Bestimmung: Wesołowska (1986). Verbreitung: Portugal bis Italien (World Spider Catalog 2015).

***Heliophanus stylifer* Simon, 1878 (Abb. 9-14)**
Mallorca: Naturpark s'Albufera, 39.785067°N, 3.129383°E, 6 m ü. NN. relativ feuchter, mit ca. 3x5 m flächenmäßig allerdings sehr kleiner Fundort inmitten eines ansonsten eher sehr trockenen und sandigen Kieferndünenwaldes. 24.03.2014: 1♀.

Die Spinne wurde als Jungtier lebend eingesammelt und im Laufe der nächsten 2 Monate zur Reifehäutung gebracht, die das Tier am 03.06.2014 vollzog. Die Bestimmung des Tieres erfolgte mit Hilfe von Denis (1937: 1053, Pl. V, fig. 1) sowie Wesołowska (1986: 43, figs 511-513) und wurde von W. Wesołowska per E-Mail bestätigt.

Alle bisherigen Nachweise der Art stammen aus Nordafrika (Simon 1878, Simon 1885, Denis 1937,

Abb. 9: *Heliophanus stylifer*, Weibchen, Dorsalansicht
Fig. 9: *Heliophanus stylifer*, female, habitus dorsal

Abb. 10: *Heliophanus stylifer*, Weibchen, Frontalansicht
Fig. 10: *Heliophanus stylifer*, female, habitus frontal

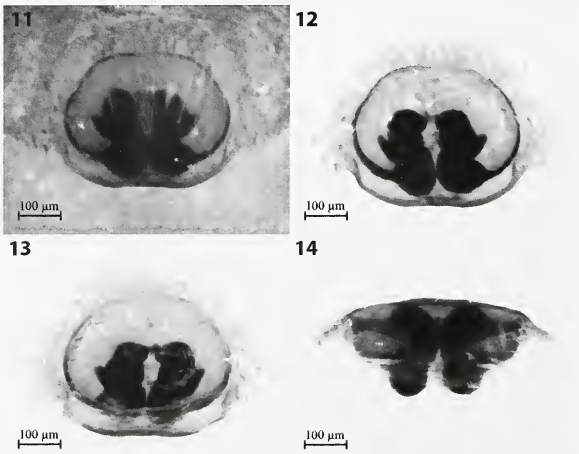

Abb./Figs 11-14: *Heliophanus stylifer*, Weibchen – female. **11.** Epigyne (am Tier – not dissected). **12.** Epigyne (präpariert – dissected). **13.** Vulva. **14.** Epigyne aboral

Wesołowska 1986), wo diese von lediglich acht Fundorten in Algerien, Marokko und Tunesien bekannt ist (Tab. 1, Abb. 15). Bei einem weiteren marokkanischen Fund aus dem Jahre 1905 sind keine genauen Ortsangaben verfügbar (Wesołowska 1986).

Tab. 1: Bisherige Nachweise von *Heliophanus stylifer*
Tab. 1: Previous records of *Heliophanus stylifer*

Algerien	
Annaba	Simon 1885
Biskra (Locus typicus)	Simon 1878, 1885, Wesołowska 1986
Constantine	Wesołowska 1986
Djebel Daya	Denis 1937
Guelma	Simon 1885
Marokko	
Douar Kef El Bya	Wesołowska 1986
Jebel Doug	Wesołowska 1986
Tunesien	
Aïn-Draham	Simon 1885

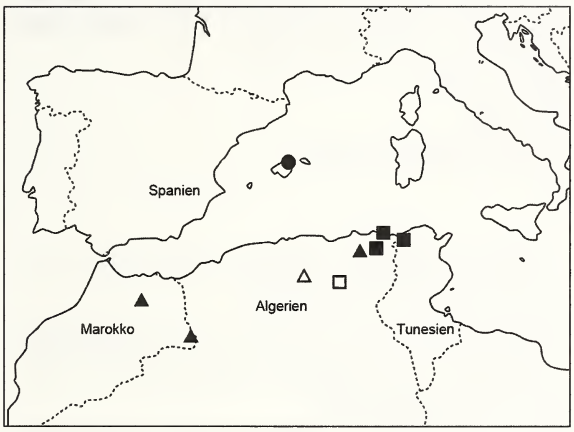

Abb. 15: Nachweise von *Heliophanus stylifer* (□ Simon 1878 (Locus typicus), ■ Simon 1885, △ Denis 1937, ▲ Wesołowska 1986, ● diese Arbeit)
Fig. 15: Records of *Heliophanus stylifer* (□ Simon 1878 (Locus typicus), ■ Simon 1885, △ Denis 1937, ▲ Wesołowska 1986, ● this paper)

Ob es sich beim aktuellen Nachweis um die Neueinschleppung einer Art handelt, die bisher nicht in Europa vorgekommen ist, oder ob diese schon seit langem autochthon auf Mallorca vorkommt, nur bisher noch nicht nachgewiesen wurde, kann nicht abschließend nachvollzogen werden. Für beide Alternativen gäbe es aber zumindest Anhaltspunkte. Für eine zeitnahe Neueinschleppung spricht, dass auch nach längerer, gezielter Suche lediglich ein Einzelexemplar der Art aufzufinden war. Für die andere Alternative spricht die im Allgemeinen eher defizitäre Datenlage zur mallorquinischen Springspinnenfauna.

***Icius hamatus* (C. L. Koch, 1846)**
Mallorca: Alcudia, 39.791994°N 3.124039°E, 7 m ü. NN. an Gebäudewand. 29.03.2014: 1♂, 1♀. Bestimmung: Alicata & Cantarella (1994), Metzner (1999). Verbreitung: Paläarktis (World Spider Catalog 2015).

***Menemerus taeniatus* (L. Koch, 1867)**
Mallorca: Naturpark s'Albufera, 39.781453°N 3.13535°E, 3 m ü. NN. auf Holzgeländer an Strandaufgang. 31.03.2014: 3♂, 1♀, Bestimmung: Metzner (1999).

Bei diesem Nachweis handelt es sich eigentlich schon um den zweiten Nachweis der Art für die Balearen. Der Erstnachweis aus dem Jahre 2009 vom Cap Andritxol (39.529184°N, 2.425040°E, 137 m ü. NN. Natursteinmauer. 20.02.2009: 1♀, det. M. Schäfer, vid. H. Metzner), wurde damals aber lediglich fotografisch dokumentiert, aufgrund der Eindeutigkeit der Fotos jedoch bereits als sicherer Nachweis in die Datenbank von H. Metzner aufgenommen (Metzner 2014). Verbreitung: mediterran bis Kasachstan, Argentinien (World Spider Catalog 2015).

***Salticus mutabilis* Lucas, 1846**
Mallorca: Alcudia, 39.791867°N 3.124228°E, 7 m ü. NN. an Gebäudewand. 31.03.2014: 2♂, 1♀; Naturpark s'Albufera, 39.7856°N 3.129033°E, 6 m ü. NN. an Kiefernstamm. 24.03.2014: 2♂. Bestimmung: Metzner (1999). Verbreitung: Europa, Azoren, Georgien, Argentinien (World Spider Catalog 2015).

Diskussion
Bei den vier neu nachgewiesenen Arten handelt es sich, bis auf *Heliophanus stylifer*, um Spezies, die im gesamten Mittelmeerraum als häufig angesehen werden können. Dass diese bisher noch nicht für die Balearen nachgewiesen wurden, dürfte an der wohl eher als mangelhaft anzusehenden Erforschung der Springspinnenfauna dieser Inselgruppe liegen. Mit bisher lediglich 20 nachgewiesenen Arten aus der Familie der Salticidae ist die Datenlage zu den Balearen im Verhältnis zum restlichen westlichen Mittelmeerraum deutlich defizitär (Tab. 2). Allein auf der iberischen Halbinsel sind bisher 128 Arten

Tab. 2: Bisher auf den Balearen nachgewiesene Salticidae (Morano et al. 2014)
Tab. 2: Salticidae, hitherto known from the Balearic Islands (Morano et al. 2014)
MA = Mallorca (inkl. Cabrera), ME = Menorca, IB = Ibiza (inkl. Formentera)

Art	MA	ME	IB	Referenzen
Aelurillus balearus Azarkina, 2006	+		+	Azarkina 2006
Aelurillus luctuosus (Lucas, 1846)	+		+	Azarkina & Logunov 2006
Bianor albobimaculatus (Lucas, 1846)	+			Pons 1993a
Chalcoscirtus atratus (Thorell, 1875)		+	+	Denis 1952b, 1961, Pons 1991
Chalcoscirtus infimus (Simon, 1868)	+		+	Denis 1952b, Pons 1991, 1993a
Cyrba algerina (Lucas, 1846)	+	+	+	Denis 1952a, 1952b, 1961, Jolivet 1953, Orghidan et al. 1975, Pons 1991, 1993b
Euophrys nigritarsis (Simon, 1868)	+			Orghidan et al. 1975
Evarcha jucunda (Lucas, 1846)	+			Bristowe 1939, Pons 1993a
Heliophanus cupreus (Walckenaer, 1802)	+			Orghidan et al. 1975
Heliophanus tribulosus Simon, 1868	+			Orghidan et al. 1975
Icius congener (Simon, 1871)	+			Orghidan et al. 1975
Icius subinermis Simon, 1937	+			Pons 1993a
Mendoza canestrinii (Ninni, 1868)	+			Pons 1993a
Menemerus semilimbatus (Hahn, 1829)	+	+		Febrer 1979, Pons 1991
Myrmarachne formicaria (De Geer, 1778)	+	+		Febrer 1979, Pons 1991, 1993a
Pellenes arciger (Walckenaer, 1837)	+			Pons 1993a
Phlegra bresnieri (Lucas, 1846)	+	+		Denis 1961, Koch 1882 (als *Phlegra simoni*, nach Bosmans & Van Keer 2012 ein Synonym von *P. bresnieri*), Pons 1991, 1993a, Pons & Palmer 1996
Salticus cingulatus (Panzer, 1797)	+			Bristowe 1939
Salticus mutabilis Lucas, 1846	+			Pons 1993a
Yllenus squamifer (Simon, 1881)			+	Logunov & Marusik 2003

Springspinnen nachgewiesen (Morano et al. 2014: Cardoso & Morano 2010 sind hier eingeschlossen). Zusammen mit den vier Neunachweisen beträgt die Anzahl der auf den Balearen nachgewiesenen Salticidae nun 24 Arten.

Danksagung
Vielen Dank an Theo Blick für die Unterstützung bei der Erstellung dieses Manuskripts.

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Heft/Volume 49 Karlsruhe, Juni 2015

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ISSN 1018-4171 (Druck), 2199-7233 (Online) www.AraGes.de